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THE DEPARTMENT OF ENERGY'S FISCAL YEAR 1997 BUDGET REQUESTS FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY AND FOSSIL ENERGY PROGRAMS

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The Department of Energy's Fiscal Y...

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

OF THE

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTH CONGRESS

SECOND SESSION

APRIL 17, 1996

[No. 71]

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*Ranking Minority Member
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THE DEPARTMENT OF ENERGY'S FISCAL YEAR 1997 BUDGET REQUESTS FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY AND FOSSIL ENERGY PROGRAMS

WEDNESDAY, APRIL 17, 1996

U.S. House of Representatives,
Committee on Science,
Subcommittee on Energy and Environment,
Washington, D.C.

The Subcommittee met at 1:11 p.m. in room 2318 of the Rayburn House Office Building, the Honorable Dana Rohrabacher, Chairman of the Subcommittee, presiding.

Members present: Representatives Roemer, Ehlers, Doyle, Rivers, McCarthy, Stockman, Largent, Fawell, Olver, Bartlett, Barcia, Schiff, Brown, Wamp, Cubin, Davis and Volkmer.

Chairman ROHRABACHER. All right. This hearing of the Energy and Environment Subcommittee will come to order.

This is the second hearing on the Department of Energy's Fiscal Year 1997 budget request. It is the result, I might add, of the request of the distinguished Ranking Minority Member of the Subcommittee to have another hearing, and this one focused on the renewable energy, energy efficiency and fossil energy programs.

As I pointed out at our March 21st hearing, we have been compelled to limit our hearings, because the budget was submitted by the President six weeks late. And, in the case of energy conservation, the President was seven weeks late.

The budget submissions of these two program offices are a study in contrast. The Fossil Energy budget requests of $348.5 million represents about a 17 percent reduction from current funding levels.

Although this figure is higher than the authorizing levels passed by the House in 1995, it reflects an effort to set priorities in light of balanced budget realities. On the other hand, the Renewable Energy budget request calls for a 35 percent increase primarily in demonstration projects and market promotion activities.

For example, there is a 427 percent increase in the request for a program that gives taxpayer money to utilities for installing more expensive renewable energy projects. The same taxpayer is still forced to pay the monthly utility bill, however.

Although listed under Research and Development, it is neither. It is a subsidy program, pure and simple.

The Administration is also requesting a 34 percent increase in the Energy Conservation budget. This increase is primarily for subsidies of industrial corporations—builders and the Big 3 automakers.

Within those programs are some startling figures. A 507 percent increase for the aluminum vision program. The glass vision program would go up 271 percent. The metal casting program, 183 percent.

Some concerns have been expressed over where this money is going. And, I have a written statement from the former DOE Metal Casting Program manager, who is too ill to testify today. And, I will put the statement of Mr. Pellish into the record.

And, without objection, it will be submitted for the record.

He expresses in his letter concern that the program reorganization has put funding authority in the hands of a small group of industry lobbyists who may well ignore small business within that same industry. This is an inherent problem when government picks winners and losers, because somebody is doing the picking and somebody may pick people they know or people they have been associated with or people they have sort of a preconceived notion might do a better job in order to receive limited taxpayer money.

That's perhaps one of the reasons the government shouldn't be making those decisions. It's hard to understand why, knowing the budget restrictions that we face, that the Department of Energy would not want to set their own priorities and present a more realistic budget for those programs.

We will have the opportunity to explore these issues with our witnesses. But, first, I will turn to my colleague from Indiana, the distinguished Ranking Minority Member, Mr. Roemer, for his opening remarks.

Mr. ROEMER. Thank you, Mr. Chairman. I, first of all, want to thank you for the opportunity to follow up on these hearings.

We requested that we have more hearings specifically in this area. You granted that request. And, we look forward to what we then glean and learn from today's witnesses.

These are critical issues under the jurisdiction of this Subcommittee. And, I am pleased that we are here to continue our work in examining the Administration's plans for the Department of Energy as it continues to refocus its mission, downsize its operations and enhance our country's ability to grow and compete in the world market.

The Administration's budget makes some notable program changes in the budget for energy efficiency and renewable energy; all told, a 34.8 percent increase over the currently appropriated total. There is also a 17.3 percent decrease in fossil energy R&D over current levels.

These changes reflect policy decisions that are of serious interest to this Committee. And, I look forward to hearing the Administration witnesses explain how these decisions were made.

Energy policy is critical to the health and well being of our citizens. It is also having great impact on our manufacturing sector and has the potential to lend great support to our ability to enhance trade and exports.

The United States has sometimes lagged behind our trading partners in energy efficiency, which is an economic engine that we cannot ignore. Energy efficiency reduces the cost of doing business and has the added bonus of being environmentally friendly.

Renewable energy policy is equally important. It is our best ally in reducing dependence on foreign energy sources.

Fossil energy programs are also critical but are no longer the single venue that we have in increasing our energy independence. All of these programs must act in concert if this nation is to achieve the proper level of investment in the resources that exist today and our ability to provide constant and dependable energy production in the future.

I would like to extend a special welcome today for our private sector witnesses. They are full partners in our energy production and energy policy infrastructure.

And, their point of view is needed by the members of this Committee as we are called on to make budget and policy decisions in the energy arena. Groups like the Alliance to Save Energy have worked hard to achieve productive and nonpartisan solutions that are, indeed, workable.

Their promotion of sensible conservation efforts deserves our recognition.

On a final note, Mr. Chairman, because we have a witness scheduled today from the General Accounting Office, I would like to comment on a GAO report that was brought to my attention this week. I guess Mr. Greenspan is commenting today on the GAO report, so it's only appropriate that we all comment on these GAO reports.

This GAO report is highly critical of the DOE publication called "Success Stories." Review of the DOE report is, indeed, welcome and desirable.

I have frequently relied on the GAO for good evaluations of federal programs in order to ensure that the taxpayer dollar is widely and fairly used. However, I must take exception to a number of the findings of the GAO report.

For example, in reviewing the DOE claims about the electronic lighting ballast, GAO fully supports the DOE's claim of significant energy efficiency but then refutes this benefit because the electronic ballast costs more than the traditional magnetic ones. Yet, GAO allows that the electronic ballast will save significant costs over time.

It is also not fair for the GAO to magnify these details without discussing other tangible benefits such as vastly improved lighting quality and noise reduction, which are important to consumers, along with better efficiency and longer life.

Similarly, in the segment dealing with battery operated cars, GAO uses what amounts to a typographical error and portrays it as a mathematical dishonesty. Better investigation by the GAO would have saved everyone, including themselves, a great deal of aggravation, time and trouble.

Finally, GAO criticizes the DOE for finding energy savings in energy efficient windows. GAO finds economic fault in the DOE claims, because the higher cost of the windows means it will take longer for energy savings to surpass the extra cost of the windows.

Then, GAO admits that the time period used does not allow sufficient time to reflect these savings. Where is the flaw?

GAO also fails to note that most utilities in this country give substantial rebates to consumers who purchase high efficiency windows, offsetting the extra cost of the purchase. This example is representative of the single, deep, overriding flaw in the entire GAO report, that saving energy is only a benefit if it saves money.

I suggest to the GAO that saving energy can, at times, be its own benefit and the fact that each one of these accomplishments may save money over the short term and over the long term. Not every DOE accomplishment in the "Success Stories" is a landmark, but there are successes that cannot be measured only in terms of money. And, the GAO should know better.

Again, Mr. Chairman, this is a very important hearing. I appreciate your cooperation in holding this.

And, I am pleased to be here and anxious to get to the business at hand.

Chairman ROHRABACHER. Thank you very much, Mr. Roemer. And, we have Mr. Li with us, of course, today who might have a few comments about your critique of this report.

Our first panel will cover some programs in the Office of Energy Efficiency and Renewable Energy at the Department of Energy.

Mr. DOYLE. Mr. Chairman——

Chairman ROHRABACHER. Yes.

Mr. DOYLE. I just have a very brief opening statement, if it's okay.

Chairman ROHRABACHER. Actually, I will approve it now. But, the policy of the Committee has been that usually the Ranking Member and the Chairman will have an opening but only because of time designations.

But, just as a favor to you, I would be very happy to let you have an opening statement.

Ms. RIVERS. Does that mean that the favor would now be extended to any others who——

Chairman ROHRABACHER. You see, we open the door.

[Laughter.]

Chairman ROHRABACHER. The Committee rules are that we don't have opening statements. But, I will give 60 seconds to anybody who would like to have an opening statement.

Mr. DOYLE. You are my hero.

[Laughter.]

Mr. DOYLE. Thank you, Mr. Chairman. I just want to take a minute to welcome Secretary Godley, who is going to be on the second panel.

We have worked very closely on the fossil energy R&D budget. And, I really think that this Committee needs to know the fantastic job she has done in downsizing her budget while maintaining core programs.

While I believe that we may have cut too far, this does not detract from the example set by fossil energy. I also want to point out that although most of the President's budget increases or maintains level funding for energy research, fossil is being asked to take a 10 percent cut.

No other office in DOE has done as much to fulfill its downsizing mission under the strategic alignment initiative. While it is one of the smallest parts of DOE, fossil energy has eliminated 150 FTEs and has closed two facilities—Elk Hills and NIPER.

In addition, supervision of all field operations are being consolidated under one management structure.

Finally, I want to urge the members of this Committee to look at what these programs do. I realize that because fossil fuels have been around awhile, there is a tendency to think that the utilization technologies have been improved to their maximum. If this logic was applied to nuclear R&D, you would come to the conclusion that since atoms haven't changed since the beginning of time, there is no more work to be done in this area.

The research being supported by fossil energy will allow us to make better use of our fossil resources and help prevent pollution. Regardless of what we do here, in the year 2010, 88 percent of energy will come from fossil sources.

I think it is common sense to continue R&D to reduce emissions and other environmental hazards. The alternative is to address these problems through economically burdensome regulations.

And, if that is the preferred alternative of those who seek to cut these programs, then so be it. But, let's just be honest with the American people about the type of choice we are making.

As for the GAO report, I look forward to the opportunity to a detailed examination of GAO's analysis. Judging by the length of the report, that should not take too much of the Subcommittee's time.

Thank you very much, Mr. Chairman.

Chairman ROHRABACHER. And, you haven't taken too much of the Subcommittee's time either.

[Laughter.]

Chairman ROHRABACHER. Ms. Rivers, do you have a one minute statement that you would like to make as well——

Ms. RIVERS. I do, thank you.

Chairman ROHRABACHER. (continuing) in the next 90 seconds?

[Laughter.]

Ms. RIVERS. Actually, I would like to raise several questions, contextual questions, as we move into this hearing. As I looked at the original materials that were sent out to us, I was interested in particular in the two enclosures of prehearing questions and issues that were submitted to the DOE prior to this hearing.

Now, I know it's not unusual to put forward a few questions. But, I was amazed to find that, not counting subsection questions, we were asking 569 very specific requests of the Committee.

And, so I would be interested in knowing, particularly after looking at the questions and seeing that many of them are not, you know, expressly directed toward FY 97 funding requests, I would be interested in knowing if these questions are so important whether we are going to wait until they are all answered before we move to mark-up; and, if we are not going to wait for them, why are we requesting them if they are not adequately important to slow down our deliberations.

And, lastly, I would like to know from the DOE if they could perhaps estimate how much time, manpower and money the DOE would have to expend in order to answer all of these questions that were put forward.

Thank you.

Chairman ROHRABACHER. Well, thank you very much. Just to note on the questions, of course, we did not receive as detailed a budget request as we are used to, or have been used to in the past.

So, many of the questions that you are referring to are questions that are logically asked of people who have not provided the information necessary for us to make those decisions. I would hope that the questions would be answered in a timely manner so that they can be part of our request.

As my staff member is suggesting that I ask, is to make sure in answer to Ms. River's question, what we also would expect is the Department of Energy to compare the length of time in answering these questions to the length of time they were required to expend in order to answer the questions when the Democrats controlled the House and controlled this particular Committee.

So, whatever that is—and, by the way, from now on, just to let you know, it is the policy of this Committee only to permit opening statements by the Ranking Member and the Chairman. And, we are trying to do that to save time.

But, I felt that it was pretty hard for me to enforce that, seeing that the Chairman of the Committee was 10 minutes late today and had expended 10 minutes by being late. So, just as a courtesy.

But, in the future, we will probably just leave ourselves with the opening statements with the Ranking Member and the Chairman. And, I don't believe there's an opening statement on this side?

Mr. LARGENT. No.

PANEL 1—ENERGY EFFICIENCY AND RENEWABLE ENERGY

Chairman ROHRABACHER. Okay. So, we will then proceed. Our first panelist is Christine Ervin, who is the Assistant Secretary of Energy for that office.

And, then we have Allen Li, who serves as Associate Director for Energy, Resources and Sciences Issues for the General Accounting Office; and, David Nemtzow, President of the Alliance to Save Energy; and, Ronald McMahan, who is President of the Resource Data International in Boulder, Colorado.

Now, without objection, all of your statements will be put in the record. But, we would appreciate if you could summarize your statements and bring it down to five minutes so then we can get on to some of the dialogue.

There have already been some questions asked. And, Mr. Li, I know that you are going to want to answer some of those questions. But, feel free to make whatever statement you want to make and let the others ask their questions during their time for questions and answers.

So, Ms. Ervin, go right ahead.

STATEMENT OF HON. CHRISTINE A. ERVIN, ASSISTANT SECRETARY FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Ms. ERVIN. Mr. Chairman, members of the Committee, I do appreciate this opportunity to present the Administration's Fiscal Year 1997 budget request for the Department of Energy's Efficiency and Renewable Energy programs.

Our total Fiscal Year 1997 request is $1.1 billion, of which $195 million, by the way, is for low income weatherization programs and state grants. This is an increase, as you suggest, from the 1996 appropriated in conference levels of about 30 percent.

And, I recognize that this is a significant increase. But, it should be put in the context that the request represents a clear ordering of departmental priorities based on their contributions to environmental quality, economic competitiveness and returns to society—very similar criteria that were used in the previous Administration to rank the various programs in the Department's energy portfolio.

The total DOE request is down 13 percent from the 1996 conference mark and down 38 percent from 1995 appropriations. And, while the efficiency and renewable request is a significant increase over last year's mark, it is nonetheless slightly below 1995 appropriations.

We have taken strong actions to reduce our administrative costs by 50 percent to streamline our programs, to eliminate lower priorities, as well as to close four support offices as of March 31st.

I also want to be very clear about the reasons for this Administration's strong emphasis on these programs. The Administration believes that the protection of the environment is a key government responsibility and that these programs are among the most cost effective ways to prevent pollution from ever happening in the first place.

At the same time, our programs are essential for providing economic security for the American family by developing technologies that lower the energy bills for Americans and by ensuring U.S. technological preeminence in industries that create high wage jobs. In addition, our programs make America more secure by reducing the nation's growing dependence on imported oil and the world's growing dependence on Persian Gulf oil.

I know you are aware that we are currently importing half of our oil. And, for those of us concerned about deficits, we should consider that this oil dependence contributes $50 billion annually to our trade gap and estimated to grow to $100 billion by the year 2010.

On the other hand, through the efforts in these programs to improve federal energy management, in particular, we can deliver $6 billion in deficit reduction through the year 2002.

Now, I know that certain Members of Congress have expressed the idea that our business should be basic research, period; that we should not be involved with efforts to see cutting edge technologies developed. I believe this is a false dichotomy.

Technology development is not a pipeline into which we pump pure research to yield a finished commercial technology at the other end. It is a constant process of readjustment and refinement. The linear model does not hold true and hasn't for a number of years.

This interaction between the stages of R&D was examined seriously by the Yergin Task Force. And, this is what they said. "The traditional division between basic and applied research is breaking down. The complexity of the problem requires interactivity between the two. And, the traditional paradigm is being replaced by concurrent R&D."

Burton Richter, former President of the American Physical Society, describes this technology R&D process as a double-helix form with constant interaction and refinement between the research lab and the marketplace, between the private sector and the public sector.

I want to emphasize that the Yergin Task Force also singled out the efficiency and the renewable energy programs in its call for continued R&D funding and directed us to develop a balanced R&D portfolio that includes industry co-funded partnerships.

Mr. Chairman, I am proud of our record of technological accomplishments. I think, in many ways, it is the story of America's success in the late 20th century.

We lead the world because we lead the world in technology. This leadership grew from our unique system of partnerships between government and industry that continue to deliver the technologies for the next century.

It is always wise to reexamine our approaches from time to time. But, I urge us to keep our eye on the outcome.

Thank you very much.

[The prepared statement of Ms. Ervin follows:]

Statement of Christine A. Ervin
Assistant Secretary for Energy Efficiency
and Renewable Energy
U. S. Department of Energy
before the Subcommittee on Energy and Environment
Committee on Science
U. S. House of Representatives
April 17, 1996

Mr. Chairman and Members of the Committee, I am pleased to be here today to discuss the Administration's FY 1997 request for the Department of Energy's Office of Energy Efficiency and Renewable Energy.

We propose a budget of $1.084 billion. These funds support a request of $369 million in the Energy Supply Research and Development Appropriations account and a request of $715 million for Energy Conservation activities funded under the Interior and Related Agencies Appropriations.

We believe this presents a balanced portfolio of research, development, and demonstration programs to provide America with a stream of successful energy efficiency and renewable energy technologies - helping prepare our nation to compete successfully in the global economy of the next century. This request is an increase over the FY 1996 Conference mark, but is below the level of 1995 appropriations. The requested increase in EERE programs represents a substantial realignment of Departmental priorities -- the total DOE request for all Energy Programs is down 13% from the FY1996 Conference mark and 38% down from FY1995 appropriations.

Energy Efficiency and Renewable Energy R&D Programs Provide Huge Returns on Investment to Our Nation

The programs to be funded under this request directly contribute to our Nation's future. In the year 2000, energy efficiency programs funded in this request are projected to cut energy demand by nearly 2 quads per year, and help businesses and consumers to save over $10 billion in annual energy costs and cut carbon emissions by over 30 million metric tons (MMT) per year. In the year 2010, these programs will assist industry in saving annually over 8 quads of energy, $70 billion in energy costs, and 150 MMT of carbon emissions reductions, including nearly 2 million barrels per day of reduced oil consumption.

Our renewable activities support research and development on new, efficient, reliable and environmentally sound renewable energy technologies for the utility, transportation, industrial and buildings sectors. Our activities also support development of advanced utility system technologies necessary for integration of renewable energy systems into the utility grid, and support initial deployment of solar and renewable energy technologies into domestic and international markets.

Our renewable energy industries and corresponding federal programs are evolving into a major National success story. Renewable energy industries, in collaboration with our National Laboratories and Federal programs, are making substantial technology and process improvements. Prices for energy delivered by renewable energy technologies have dropped by orders of magnitude, from 90 cents per kwh to 20 cents in 1995, for photovoltaics; from 40 cents per kwh to 5-6 cents in 1995, for wind; from 9 cents per kwh to 5 cents for geothermal energy. This progress has been made through sustained federal R&D efforts to improve the technology over the past 10-15 years. It is important to emphasize this final point. The success in the renewable energy industries in recent years is directly related to long-term support and a multi-year programmatic focus designed to foster and accelerate the progression of technologies from the laboratory to the marketplace. Now, our renewable energy industries are poised to capture burgeoning domestic and international markets.

These programs deliver substantial benefits by cutting business costs, adding new high-wage jobs to our economy, improving environmental quality, reducing long-run health costs, maintaining stable energy prices and enhancing energy security. They provide competitive advantage and economic benefits to U.S. businesses, industry and citizens. Let me touch briefly on three of these points.

Cutting Business Costs - Improving Economic Security

Today, considerable capital is wasted on inefficient equipment and pollution controls by American businesses and industry. But decision-makers across our nation are discovering that investments in energy efficiency technologies cut costs - freeing up monies that can be used to increase wages or capital investment - a potential source of investment capital for both the firm and the economy. This investment capital can make companies and their products more productive and more efficient, thus more competitive in world markets. In addition, companies manufacturing energy efficiency and pollution prevention technologies and developing renewable energy technologies can compete in the emerging trillion dollar global market for energy and environmental technologies, representing the potential to return millions of dollars in sales to our domestic economy.

Improving Environmental Quality

The production and use of energy causes more environmental damage than any other economic activity in the world today. Without significant changes in energy sources and consumption patterns, the problem will grow inexorably worse. Energy use in the United States is projected to rise 19% between 1995 and 2015, while world energy consumption is expected to rise by a third over the next 15 years. Costs of *controlling* this related pollution are huge and expected to rise. However, there is a better way. Cleaner energy sources and energy efficiency technologies can *prevent* this pollution at a fraction of the cost of control and provide real economic returns on investment to business and industry. Energy efficiency technologies provide an important path to minimizing the environmental impacts of energy while simultaneously spurring economic development.

Maintaining Energy Security

U.S. oil imports as a share of consumption are approaching record levels and the Energy Information Administration projects that this dependence could grow to nearly 60% within 10 years. This dependence aggravates the trade deficit and leaves the American economy vulnerable to oil price shocks - with potentially severe economic impacts. Energy efficiency technologies in transportation and industry can substantially cut the growth of oil imports while simultaneously making our economy more resilient in the face of possible future price shocks.

The challenge DOE faces in FY 1997 is to produce beneficial new technologies with fewer resources, maintaining the vital contribution of energy efficiency and renewable energy in the Administration's and Congress' vision. To meet this challenge, our FY 1997 Budget Request proposes funding for programs that will leverage significant non-Federal investments and will produce high economic, environmental and energy-security benefits, while accelerating the entry of U.S. technologies into the global marketplace. We will continue to work in partnership with industry, utilities, consumer groups, and State and local governments to leverage our efforts and ensure that our customers make effective use of energy efficiency technologies.

By the year 2000, the investment contained in the FY 1997 budget request will more than pay for itself in the value of energy cost savings that every energy consumer in our Nation will receive. These savings are likely to be spent on domestic goods rather than foreign oil, so billions of dollars will be added to the U.S. economy. Just as important, the investment in energy efficiency technologies will prevent millions of tons of air, water and ground pollution benefitting every person in the United States, particularly the 150 million people living in the 190 areas that do not currently meet the air quality standards of the Environmental Protection Agency.

This Budget Request Represents a New Way of Delivering Returns to Taxpayers

In addition to modifying our portfolio to meet new futures, the Office of Energy Efficiency and Renewable Energy is re-engineering HOW we offer it. We are reinventing how government interacts with the private sector.

- We are working more closely with the American public, our customers, building voluntary partnerships with industry, business, state and local governments and energy consumers.
- We are using relatively small amounts of Federal money to leverage large amounts of private investment.

- We are stressing flexibility and innovation to be responsive to our customers.
- In a time of fiscal austerity, we are cutting administrative costs and overhead, downsizing operations and operating more efficiently.
- We are committed to continuous improvement, customer involvement and market-driven action. We are striving to operate more like a business, and less like a bureaucracy.
- Rather than offering vague promises of progress, we are setting clear goals and annual progress targets so that we are accountable for real results.

In the following sections I summarize the specifics of our request and discuss our accomplishments to date and the results it will return in the future.

Utility technologies

For utility-related renewable energy and energy efficiency programs, we are requesting $295 million in FY 1997. By the year 2000, over 1 quad of renewable energy capacity will be installed domestically, growing steadily to 4 quads by 2020. We also estimate that our utility technology programs will reduce emissions by the equivalent of over 7 million metric tons of carbon euqivalent by the year 2000. By 2020, this is projected to rise to 75 million metric tons of carbon equivalent.

To achieve our goal to help America's electric power producers develop clean, renewable and more economical forms of energy, we focus on three principal missions: 1) To develop new technologies for electric power from renewable resources, including solar, wind, geothermal, and biomass energy; 2) to help the power industry address technical and institutional barriers that prevent energy efficiency and renewable energy systems from reaching full market potential; and 3) to work with the utility sector, regulators, and state governments to help them apply long-term planning that promotes consistent treatment of all resource options.

Photovoltaics

The FY 1997 request is $87 million for DOE's PV programs. These programs are on track for achieving the goal of having 1000 MW capacity of domestic (and 500 MW of foreign) grid connected systems in place by the year 2000. To help meet this goal, in FY 1997 we plan to concentrate on: (1) fundamental research and development; (2) thin film research and development partnerships; and (3) collector research and development that includes PVMat and PV Compact. DOE-funded PV projects typically require 50/50 cost share with industry and these dollars also generate an approximately five-fold increase in private investments in PV manufacturing plants and systems.

Specific key elements of the FY 1997 PV funding request include the Photovoltaics

Manufacturing Technology (PVMaT) program and the complementary PV:BONUS (Building Opportunities in the U.S. for PV) and the UPVG (Utility PV Group), which work cooperatively with industry groups to accelerate PV market penetration and will install about 5mw of PV systems through UPVG efforts.

Solar thermal

The budget request of $24 million for Solar Thermal Energy Systems is divided between utility and industrial programs. Of this amount, $18 million is directed to solar thermal power programs for utility and other power-producing applications. The remaining $6 million will be spent on industrial solar detoxification activities.

In the utility sector, the Solar Thermal Power Program works to develop new utility generating systems with higher efficiency and reliability for greater availability and dispatchability (power towers); distributed systems with high modularity (25 kWe dish/engine systems); and off-grid systems having both domestic and export potential (7.5 kWe dish/Stirling engine systems) and will complete evaluation of the 7.5 and 25kw dish/sterling prototypes.

Earlier this year, we finalized construction of Solar Two, begun in 1992 with a consortium of eight U.S. utilities led by Southern California Edison. We are currently working on system integrity and validation checks. Further testing at full power will begin after this year and provide the extended data needed to build utility confidence in power tower technology. Solar Two is a $48.6 Million, 50/50 cost-shared cooperative project with DOE and industry to convert an existing 10-MWe water/steam power tower to a higher-efficiency molten salt system that can meet both peak and intermediate power demands.

Similarly, both the 25 kW and the 7.5 kW systems are industry-driven, 50/50 cost-shared programs that will be continued in FY 1997. The 25 kW project is expected to result in operational prototype installations exceeding 1MW in size. A key program goal is to achieve commercial introduction by industry in all two sizes before the year 2000.

Several other significant solar thermal projects also fall within this category, for which development of these systems is cost-shared 50/50 with an industry consortium led by Cummins. SolMat, begun in FY 1994, is patterned after the very successful PVMaT program. SolMaT engages in 25% industry cost-shared projects to improve manufacturing productivity, cost-competitiveness, and quality control improvements needed to help the United States retain its status as the worldwide manufacturing leader.

Wind energy

The FY 1997 funding request for wind programs is $50 million. The price of wind energy has dropped substantially, from 40 cents a kilowatt hour in 1980 to as low as 5-6 cents today, within range of the 3-5 cent average production cost of conventional electricity. Wind is already producing enough electricity for 1 million Americans, and continued R&D is projected to bring costs down to 4 cents or less by the turn of the century. We estimate that by the year 2000, 3000 MW of new wind capacity will be installed and over 3000 new jobs will be created. DOE will partner with industry to prove the technologies through up to 20 targeted deployments in various regions across the country, with a minimum 50% industry cost-sharing.

Biomass power

We are requesting $35 million for utility-related Biomass Power programs in 1996. Integrated bioenergy projects may provide significant benefits to the U.S., including rural development, job creation, and an opportunity to significantly reduce the nearly $2 billion in annual Federal agricultural subsidy payments through the introduction of alternative energy crops. We will continue the DOE/USDA collaborative Energy Partnerships/Biomass Power Initiative in FY 1997, which focuses on demonstrating the economic and environmental viability and sustainability of integrated feedstock production and power conversion technologies through partnerships with farm communities to produce reliable supplies of biomass feedstocks and cost-competitive electric power.

Biofuels - Transportation

Biomass to ethanol, or bioethanol, is the only major renewable option being pursued in the transportation sector that lowers greenhouse emissions and promotes energy security through direct oil (gasoline) replacement. Each year over one billion gallons of ethanol, primarily from corn, are blended directly into gasoline in the United States and used, without modification, in internal combustion engines. Major U.S. car and light duty (pickup) truck manufacturers are stepping up their commitment to ethanol. Over 6,000 cars in 1996 and possibly 15,000 cars in 1997 of one of America's most popular family sedans (the Ford Taurus) are being produced that are capable of running on an ethanol/gasoline blend that contains 85 percent ethanol. General Motors plans to market over 100,000 pickups in 1997 that will also be designed to run on 85 percent ethanol blends. All of these alternative fueled vehicles will be offered at no incremental cost above conventional models.

The ethanol industry has relied on converting starch, primarily from corn, to ethanol. However, the tremendous need to produce vast quantities of biomass in an environmentally sustainable way to meet the challenges of decreasing oil imports and greenhouse gas emissions has required the Department to invest in new technologies that convert grasses, trees, and cellulosic wastes that are in potentially abundant supply to produce bioethanol. The FY 1997 investment of $40.5 million in the transportation biofuels program will support continuing research and development of technology for producing cost-competitive ethanol from low-cost waste feedstock. This is a vital step on the path to biomass ethanol fuel prices in the competitive range by 2009. Several companies now believe that their technology is ready for small commercial applications in niche fuel markets. The cornerstone of the FY 1997 biofuels program is to provide support for an industry partner to initiate the construction of a cost-shared, small-scale commercial bioethanol unit. In the year 2010, biomass ethanol will displace 6.3 billion gallons of gasoline. Farm-produced feedstocks for this fuel will create 18,000 net jobs in the U.S. and will generate $1.5 billion in farm income from land that would otherwise lay idle.

Biofuels - Industrial

The FY 1997 request of $5 million will fund the Biomass for Cogeneration Project. The goal of the project is to allow biomass derived fuels to be burned in a cogeneration plant using a combustion turbine. Switching from clean natural gas to biomass fuels in combustion turbines is a significant change. Cogeneration system efficiencies can reach a significant improvement over 35% efficiency when the production of steam and electricity are separated.

Geothermal

The Geothermal Systems request for FY 1997 is $31 million and completes several technology development efforts that clearly support significant system cost reductions in the near term related to drilling, power plant, and materials technologies. The proposed program represents continuing cooperative efforts with industry to reduce the cost of power generated from moderate temperature geothermal resources by 30% by the end of this decade, leading to an expansion of the domestic geothermal generating capacity to 3500 MW and a 1000MW per year share of the international geothermal markets in the same time frame.

Hydrogen

The FY 1997 request for Hydrogen research and development is $11 million. The Department will continue its to support the development of cost competitive hydrogen technologies and systems that will reduce the environmental impacts of energy use and enable renewable energy resources penetration into the U.S. energy mix. The program will conduct a core research and development effort in critical mid- to long-term production, storage and transport technologies for application in renewable energy systems; cost-share with industry on hydrogen production by photochemical, gasification and reforming processes for near-term market introduction; and undertake industry and public outreach and education to improve technology transfer for application of research results.

Electric Energy Systems

The budget request of $32 million for Electric Energy Systems continues to address both the changing nature of the industry and carry out the requirements of the Energy Policy Act. Public concern regarding possible health effects from exposure to electric and magnetic fields (EMF) drives the DOE program to conduct health effects research, exposure characterization, field management, and communication in close cooperation with the National Institute of Environmental Health Sciences.

The Systems and Materials element has achieved significant progress toward developing practical high-temperature superconductivity technology, with payoffs anticipated within the next 5-10 years. The potential for energy efficiency increases is huge. For example, projections indicate that by just replacing today's conventional large motors (125+ horsepower) with superconducting designs, more than ½ Quad of energy per year would be saved. Successful HTS devices will also translate into widespread efficiency improvements in generation, transmission, distribution, and other end uses. In compliance with EPACT, DOE has entered into collaborative ventures with industry, both through CRADAs and the Superconductivity Partnership Initiative (SPI). Through a unique teaming structure involving component suppliers, manufacturers, and potential users, DOE cost shares (50/50) projects to develop critical products such as motors, generators, current limiters, and electric transmission cables. Industry views DOE participation as critical if the United States is to capture a significant share of the worldwide market potential for sales of products incorporating superconductive components. The Department of Commerce estimates that the worldwide market will be $8 billion by the year 2000, and an astounding $150 billion by 2020.

Energy storage

The FY 1997 Energy Storage Systems request of $4 million will fund development and deployment of battery storage systems for utility requirements, particularly for those identified in distributed utility scenarios. Utilities are increasingly recognizing that distributed storage systems will be important part of their future resource mix. By 2010, program estimates indicate that up to 100 GW of new battery storage capacity could be deployed -- the equivalent of up to 15% of the 1993 installed generating capacity.

In-house Energy Management(IHEM)

The FY 1997 request is $5.7 million. The Department of Energy's In-House Energy Management (IHEM) Program, under the direction of the Federal Energy Management Program, will reduce Departmental energy costs $150 million annually by 2005. The Department will continue its efforts to set a good example for energy efficiency in the Federal government by reducing energy and water consumption, improving energy efficiency, and reducing utility costs throughout the Department's facilities and operations. The IHEM Program is currently saving the Department over $100 million annually through its investments in energy efficiency and renewable energy projects. The IHEM Program has had a return on investment of over 25 percent, with a net return of $5 in energy or water savings for each $1 invested at DOE facilities, not including the additional environmental or productivity benefits. Despite this success, there is still considerably more potential energy savings. In FY 1997 this program will continue to emphasize energy management within the Department by accomplishing these projects through leveraging with non-Federal resources such as utility rebates and private-sector financing.

Transportation Sector

Consuming less energy--and different forms of energy--to meet our requirements for mobility can make a significant contribution to improvements in air quality, and to arresting our growing reliance on petroleum. The direct impact of imported oil on our balance of trade is currently $50 billion a year. Of equal concern is the vulnerability of world oil prices to disruptions in oil supplied by the Middle East, which currently accounts for 28 percent of world petroleum production.

The $221.3 million requested for transportation-related activities will enable the Department to continue building the important foundation for a "revolution" in transportation. This investment will allow us to significantly alter current projections of United States demand for energy, particularly oil, after the year 2005. As technologies developed through programs, such as the Partnership for a New Generation of Vehicles (PNGV), penetrate the market, the peak of U.S. transportation oil use will decline due to efficiency gains and the use of alternative fuels.

Maintaining U.S. leadership in transportation technologies is vital for a strong and competitive economy. U.S. producers must be leaders in new technology development and deployment, have access to and use the most scientific, engineering and production breakthroughs, and make investments in both production capability and the infrastructure required to support departures from current technology. Changing future fuel use and emissions will require sustained commitment and significant investment. Working in partnership with vehicle manufacturers, component suppliers, States, and others, the Department of Energy's overall goal is to provide consumers with cost-competitive transportation options simultaneously reducing oil demand and greenhouse gas emissions. The importance of this goal is underscored by the Department's request for increased funds, despite the recognized need to reduce overall Federal expenditures.

Improved Fuel Economy

A fiscal year 1997 budget request of $148.8 million will support the continued development of technologies to achieve the objective of tripling automobile fuel economy by 2004. The investment in hybrid vehicle development will result in a vehicle propulsion system that doubles fuel economy by the year 2000, and is a necessary step in achieving the 2004 goal. ***For an investment of less than $1 per automobile per year,*** for all automobiles in use, the Department is working with its national laboratories and U.S. industry to develop and introduce propulsion, energy storage, control, and materials technologies. Drivers of fuel efficient vehicles using these technologies will save $440 in fuel expenses in the first year, assuming 13,000 miles driven, and $1.36 per gallon fuel costs, and, over the life of the vehicle, about $4,400 in fuel expenses, assuming 130,000 miles over 13 years. These savings are based on the conservative assumption of relatively constant oil prices through the next several decades. If we experience oil price shocks, as we have in the past (the last one in 1991 doubled world oil prices for a few months and caused gasoline prices to rapidly increase by 25 cents per gallon), then the benefits to both drivers and the nation will be even greater. The automotive technologies program will also result in much cleaner cars and light trucks: over their life, these new vehicles will produce 7.8 fewer tons of carbon dioxide (the major greenhouse gas) per vehicle than conventional cars.

The $7.2 million requested for the Heavy Duty Engine R&D program will continue work with the three major heavy duty diesel engine manufacturers to improve the energy conversion efficiency of diesel engines to 50 percent by 1999 and 55 percent by 2002. The goal is a fuel economy improvement of 22 percent relative to current engines, which would save $3,700 per year in diesel fuel costs for each new truck. Additionally, the emissions of these new engines will be reduced by 60 percent. When these new engines fully penetrate the market place, the nation will realize an energy cost savings of approximately $4.2 billion per year.

Producing marketable ceramic components for vehicle engines, and using them to reduce exhaust emissions and improve fuel economy, will occur from the successful completion of the Advanced Ceramic Manufacturing Technology projects with industry, started several years ago under the Propulsion System Materials Program. The objective is to develop manufacturing technology for mass producing low cost and high quality diesel engine components, including engine valves, fuel injector plungers, and turbocharger rotors. Success will be measured by producing higher volumes of ceramic components, and testing some of them in engines. The research and development program encompasses cost modeling, powder processing, continuous sintering, intelligent processing, statistical process control, component machining, inspection, and testing. Commercial success will be assured by conducting the research with teams, led by ceramic companies, and including diesel engine manufactures and equipment suppliers.

Alternative Transportation Fuels

Between now and the year 2000, increasing the use of alternative fuels will be the primary means for changing transportation energy consumption patterns. While the absolute amount of oil use will not be affected greatly before the end of the decade, the programs established now are vital to achieving significant use of alternative fuels by the year 2000 and beyond.

Much of the budget request for alternative fuels is to support activities which stimulate near-term deployment. The Department's alternative fuels program continues to emphasize the leveraging of its funds by forming, promoting, and supporting new partnerships. By joining Federal agency fleet initiatives with those of other fleet owners--through the Clean Cities Program, for example--the opportunity exists to create orders for larger numbers of alternative fuel vehicles. As a result, manufacturers are offering more vehicle models fueled by natural gas, ethanol and electricity, and the number of refueling sites continues to grow.

With the $10.9 million requested for alternative fuel vehicle (AFV) deployment in FY 1997, the highly successful DOE Clean Cities program will expand from 44 cities in 24 States to 55 cities in 35 States. To address a major customer concern over regional fuel availability, a Clean Corridors program will link these Clean Cities along major interstates. Our goal is to help the national alternative fuel vehicle fleet to grow from 385,000 to 435,000 in 1997, which would remove 87,000 metric tons of carbon from the air. For the first time, AFVs will be on the floor in dealers showrooms, many priced the same as their gasoline counterparts. These vehicles will be offered to a well-informed public as a result of the Department of Energy responding to 10,000 telephone inquiries, distributing over 100,000 brochures and documents, and sponsoring of town hall meetings and media events. Students will ride safer and cleaner on the next generation ULEV-CNG school bus. The prototype bus will be introduced on Earth Day '96, but orders for 1997 delivery are already being processed. By the year 2010, 100,000 barrels of oil per day are projected to be displaced as a result of alternative fuel vehicle programs and 0.8 million metric tons of carbon-equivalent emissions will be eliminated per year.

$14.4 million is being requested for alternative fuel vehicle research and development activities. Research will continue on ways to reduce the cost of light duty compressed natural gas (CNG), ethanol, and liquefied propane gas (LPG) vehicles. Success in this area could lead to over 500,000 alternative fuel vehicles by the turn of the century. Ultra-low emission vehicle (ULEV) ethanol and propane automobiles will be fully developed and demonstrated in FY 1997. Further work on these types of vehicles will provide for increased fuel economy, translating into operational cost savings for the consumer. Development of alternative fuel technology for heavy vehicle engines, capable of using alternative fuels, will also continue. Currently there are over 400 heavy vehicles operating in DOE field test evaluations. Data collected on these vehicles indicate that advantages exist for alternative fuel operation relative to operation on petroleum-based fuels, when impending emissions regulations are taken into account.

Buildings Technologies, State and Community Programs

Since I testified before this committee last year, we have, as part of our Strategio Realignment Initiative, merged the Office of Building Technologies and major components of the Office of Technical and Financial Assistance, including the Weatherization Assistance Program, the State Energy Program, and the Municipal Energy Management Program. The resulting new Office of Building Technology, State and Community Programs melds the scientific and technical capacity of the buildings programs with the extensive field experience, well-developed information transfer network and outreach expertise of the former OTFA. Newly structured, we are confident that the organization will provide enhanced leadership to make the nation's building stock more efficient, comfortable, affordable and sustainable. The FY 1997 request for the Building Technology, State and Community Programs is $319M, of which $195.5M is for weatherization and grants.

The energy used to heat, cool, and light our buildings - and to provide the wide array of building-related comforts and services that help create our quality of life - now costs consumers over $200 billion per year. Home energy costs the average household 6 percent of before-tax income, and costs very low income households over 12 percent. Reducing these costs would increase discretionary income, and create more jobs and economic growth if spent on goods and services other than energy.

Less obviously, energy use in buildings creates a significant portion of our environmental problems. Energy use in buildings account for one-third of our total energy use and two-thirds of the electricity consumed in the United States. Energy use in buildings now causes atmospheric carbon dioxide emissions of almost 500 million metric tons [nearly 2 tons per capita] of carbon annually - 8 percent of the global total, and more than the entire emissions of Japan and the United Kingdom combined. Energy use in buildings is also responsible for half of U.S. sulfur dioxide emissions.

Although dramatic improvements are being made in the efficiency of many aspects of energy use in buildings, these are being overwhelmed by strong sectoral growth and increasing demand for energy services such as air conditioning. Energy use in buildings is currently forecast to increase 10 percent by 2010. To offset this potential increase, DOE plans to achieve an overall 15 percent improvement in buildings energy efficiency by 2010. This would:

- ***save consumers from $22 billion up to $39 billion annually*** by 2010, and up to ***$700 billion cumulatively*** through 2020;

- ***reduce carbon emissions by 60 to 100 million metric tons*** annually by 2010.

These benefits will be achieved by an approach which has three components:

- supporting ***Research and Development*** to create the best new, cost-effective, and environmentally friendly technologies and bringing these technologies to the market with private and public sector partners;

- ensuring broad access to and acceptance of improved technologies and practices through ***Technology Introduction and Market Conditioning*** activities such as providing credible information and stimulating volume purchases; and

- providing a floor ensuring economically minimum levels of energy efficiency for appliances and equipment and supporting state and local activities on building efficiency codes for whole buildings through legislatively- mandated ***Appliance and Building Standards***;

To implement this approach in the most cost effective way, DOE has redesigned key elements of its program, and has defined "***a new way of doing business***". We are ***consolidating some programs providing grants to states***, and to improve programs results, provide greater flexibility to address particular energy and environmental issues from a State perspective, streamlining regional offices saving over $30 million in administrative costs over the next 5 years. We are ***emphasizing partnerships, consortia and collaboratives*** with the private sector to add expertise, build momentum, reach more customers faster, and increase leverage. And we are ***reinventing the appliance standards process*** to improve quality, increase stakeholder involvement, and reduce confrontation and time requirements to achieve standards which benefit both consumers and manufacturers .

Key program investments include:

- For residential buildings, ***Building America*** has the goal of improving the energy efficiency of new homes by up to 50% percent without increasing first costs. Four industry consortia have been formed, the first test houses will be operating in FY 1996, and housing developments and improved versions will be addressed in FY 1997. We are requesting $6.7 million for this project.

- For commercial buildings, ***Rebuild America,*** for which we are requesting $10.1 million, has the goal of obtaining commitments to improve the energy performance of 400 million square feet of commercial floor space by 25 percent in FY 1997, and create 250 partnerships to retrofit more than 2 billion square feet by 2000.

- ***Technology Introduction Partnerships*** has created a 20 percent efficiency upgrade package for manufactured housing; 1000 of these packages are planned to be sold in FY 1996, and 10,000 in 1997. The program has also stimulated a volume purchase of 20,000 highly efficient refrigerators in FY 1996, with an additional 30,000 planned for 1997. We are requesting $11.9 million for this project.

- ***Building Equipment R&D***, has licensed two advanced natural gas technologies - residential gas absorption [GAX] heat pump and commercial chiller - to major manufacturers; commercial introduction of both is expected in 1999. The sulfur lamp has been demonstrated in several locations; initial commercial units will achieve 100 lumens per watt, increasing to 135 by FY 1999. Our request for these space conditioning and lighting research activities is $16.2 million.

- The ***Building Codes program*** has provided State grants to assist builders and code officials to update their building codes, released MECcheck software to assist them in enforcing those codes, and released the Home Energy Rating System Guidelines to create consumer demand and enable builders to market energy-efficient homes. In 1997 we will provide technical and financial assistance to help states implement their home energy rating systems and updated energy codes. The request for the Building Codes program is $15.8 million.

- The ***Lighting and Appliance Standards program***, for which we are requesting $8 million, will increase stakeholder participation through an analytically-based consensus process, revise efficiency test procedures to ensure that innovative designs are fairly tested, and conduct a new labeling initiative to help states and utilities promote their own conservation and demand side management programs.

- The ***Affordable Homes for Low Income Housing program***, for which we are requesting $3.1 million, provides technical support to HUD, public housing authorities and local community housing providers. It is anticipated that these organizations will commit to 30 percent efficiency improvements in 100,000 public housing units in FY 1997, increasing to 1 million units by 2000 - reducing the need for energy subsidies by $200 million per year.

Federal Energy Management Program(FEMP)

Through the Federal Energy Management Program (FEMP)'s efforts, the Federal Government has already achieved success in energy efficiency and cost savings. Fiscal year 1996 highlights show that Federal energy consumption continued to fall, resulting in more than $900 million in annual energy savings by the end of FY 1994, with cumulative savings of $7.4 billion (1984 constant dollars) from the 1985 baseline. In FY 1994 the Government surpassed the 1995 goal by achieving an 11.2 percent energy reduction in buildings. Three agencies -- the Departments of Energy and Justice and the Federal Emergency Management Agency -- have already achieved 20 percent reductions, with 10 more agencies exceeding 10 percent reductions. As the world's largest single energy consumer, the Federal government demonstrates leadership by investing in energy efficiency practices that will reduce energy consumption in its facilities by 30 percent in 2005, saving a cumulative $20 billion by 2015. FEMP will equip Federal energy managers to make wise energy investment decisions to reduce government costs $1 billion annually by 2005. The FY 1997 request for FEMP is $31.9 million.

In FY 1997, FEMP will partner with Federal agencies to expand the range and availability of energy project financing mechanisms, emphasizing private sector funding through Energy Savings Performance Contracts, utility incentive programs, and including efficiency services in utility area-wide contracts. FEMP will award six new major energy saver performance contracts to make it simpler, cheaper and faster for government agencies to save energy and that will have $250 million investment potential per contract over ten years. In addition, FEMP plans to apply 15 energy and money saving technologies used in the "Greening of the White House" to three additional showcase buildings and existing Federal facilities.

To help deliver an economic and secure energy future, the Federal Energy Management Program will deploy cost-effective energy and water technologies, as well as solar and other renewable energy, as a means to reduce energy costs in Federal facilities. Twenty-two Federal agencies have committed to using the buying power of the Federal Government to reduce operating costs for Federal agencies, expand markets for the latest energy efficiency and water conservation products, and create new entry markets for advanced energy-saving technologies and products. This will stimulate lower unit costs from volume buys.

There is a strong commitment to environmental excellence in Federal agencies, however, they need good information, education and programs to help make the best decisions. With the right support, our government can set a good example and lead the way to reduce and prevent pollution. As part of the Department's environmental stewardship, in FY 1997, FEMP proposes $7 million to apply existing technology deployment mechanisms to DOE and Federal facilities. FEMP will provide technical assistance to Departmental elements to implement a joint demonstration program for chiller replacements and steam plant conversions as a pilot for expanding this effort to all Federal agencies. FEMP will work with DOE HQ program managers and program managers at DOE facilities to identify chiller retrofit projects and steam plant conversions and explore energy savings performance contract opportunities. In addition, FEMP will work to advance Federal facility energy management through incorporation of technology deployment lessons learned in Federal facilities. This effort will explore the potential Federal sector benefits of CCAP programs, such as Technology Introduction Partnerships, NICE3, Rebuild America, Climate Challenge, Climate Wise, Motor Challenge, among others, and extend them into the Federal sector as appropriate.

Industrial Technologies

Industrial energy efficiency is critical to the U.S. economy and inextricably linked to our ability to efficiently manufacture the goods and services for the nation and improve our environment. Its importance is indicated by the fact that industry consumes about 31 quads of energy (37 percent of all energy in the U.S.) at a cost of nearly $100 billion annually. In addition, industries currently spend about $48 billion a year for pollution control.

Our programs are predicated on the position that we can have economic growth and improve the environment at the same time. Industry agrees. Industry is developing its vision of how to achieve both energy and environmental savings through improved process and materials efficiency in seven energy intensive industries. DOE's role is to challenge and catalyze the creative capabilities of industry to achieve these mutual goals.

The pulp and paper industry is a key example. In the development of the Industries' vision, Agenda 2020, the industry established a research vision that is already playing a role in deliberations with the Environmental Protection Agency in meeting environmental goals. This research agenda will provide for resource and energy efficient technologies that will achieve enhanced environmental protection at a significantly reduced compliance cost. Industry estimates it could reduce its compliance costs from about $11 billion to $3 billion. The Agenda 2020 process is being followed in other energy intensive industries and represents our philosophy of how to partner with industry to provide the research necessary to achieve national objectives. I am pleased to relate that in addition to forest and paper products, we have already signed commitments with several other industries including steel and metal casting, and expect to sign with the glass industry this month.

In FY 1997, the request for Industrial Technologies is $159.4 million. Within this amount, $74.4 million directly relates to the Industries of the Future program, that will fund near, mid, and long term research and development to improve industrial energy efficiency, increase productivity and improve our ability to retain manufacturing excellence in seven key industries--forest and paper products, steel, metal casting, glass, chemicals, aluminum, and petroleum. These industries employ 2.7 million workers directly and provide basic materials to the entire U.S. manufacturing sector which employs over 18 million workers. A number of projects will be supported. In the aluminum area for example, the FY 1997 request provides for the start of pilot scale aluminum spray forming tests supporting the Partnership for a New Generation of Vehicles. This breakthrough technology will allow for improved productivity and lower cost of light weight auto materials. In the petroleum area, funding will provide for completion of a partnership with industry to improve industrial burner design that will reduce air toxics formed in the combustion process as well as other ongoing projects. In steel research, funding will be used for ongoing projects for advanced process control and field test of nickel aluminide rolling mills. In the forest and paper products industry, funding will support a variety of technologies including high solids black liquor firing, low lignin content pulp production, recovery boiler modeling and control, innovative non chlorine bleaching, and sensors for improved process control. Another part of this request provides funding for the textiles industry, which is an ongoing program which was transferred from the Office of Energy Research and the Office of Defense Program's technology transfer program.

We are also requesting $39.4 million for Crosscutting Technologies to address research needs common in all of the Vision Industries. This includes cogeneration and advanced industrial materials. As a result of the FY 1997 funding, we expect to achieve a field test of ceramic components including combustor and turbine blades that are key to achieving higher efficiency and lower emissions. These activities will move us toward commercial introduction of advanced turbine systems in the year 2000. We are utilizing a number of Departmental resources including the DOE laboratories through the Industries of the Future Laboratory Coordinating Council to apply the best the Department has to offer to this exciting program. FY 1997 funding will increase our efforts with these important industries.

In FY 1997, we are requesting $37.8 million for Technology Access Programs that facilitate and promote the introduction of advanced, energy efficiency, renewable energy and pollution prevention technologies to industry. This program represents a major part of the Administration's commitment to addressing global climate change. DOE works closely with industry, Federal, State and local governments, industry and trade associations, inventors, universities and others to expedite adoption of advanced technology that can achieve substantial reduction in energy and carbon dioxide emissions that affect climate change. This strategy is carried out through five programs.

The Industrial Assessment Center (IAC) Program provides energy and waste assessments to small and medium sized manufacturers using engineering faculty and students at over 30 university engineering departments throughout the country. This program has already provided technical assistance to manufacturers in 43 states resulting in over $400 million in energy savings at a Federal investment of $33 million. FY 1997 funding will continue these efforts.

The Motor Challenge Program works with industry to increase market penetration of energy efficient motor-driven systems. When these are widely adopted, industry could save $1.5 billion per year by the year 2010. Motor Challenge already has more than 1,200 partners and has reached over 10,000 end users through video conferencing and information outreach efforts.

The National Industrial Competitiveness through Energy, Environment, and Economics (NICE3) program provides funding to State and industry partnerships for projects that demonstrate advances in energy efficiency and clean production technologies. This is another example of win-win opportunities for businesses that are able to enhance their productivity and the American public who will reap the benefit of cleaner air and water. To date, NICE3 has sponsored 46 projects in 21 states with 55 percent cost sharing from the partners. The Federal investment of about $12 million has leveraged projects with a total value of savings of over $53 million. These savings will continue to accrue annually, increasing the value of the program's benefits. FY 97 funding will expand the program to provide additional partnerships.

The Climate Wise Program was established to develop voluntary energy partnerships with industry to reduce greenhouse gas emissions rather than rely on command and control policies of the past. To date, more than 60 Climate Wise partners, representing 6 percent of industrial energy consumption have committed to a reduction of five million metric tons of carbon equivalent by the year 2000. Climate Wise companies are expected to realize $600 million in annual energy cost savings in the year 2000, due to the investments they make that our stimulated by information from this program. The FY 1997 request is $3.4 million.

The Inventions and Innovation Program will continue to offer opportunities for inventors, innovators and entrepreneurs to make their energy-related ideas into a commercial reality. To date about 25 percent of the inventions have been commercialized, generating cumulative sales of over $900 million. This program taps the creativity of the small entrepreneur and businessman that creates the industries of tomorrow.

Policy and Management

The $28.4 million requested for Policy and Management supports program management at Headquarters and program implementation activities at the Golden Field Office and the Regional Support Offices. Also included are important initiatives in International Market Development and Information Outreach activities transferred from the Office of Technical and Financial Assistance as part of our Strategic Realignment Initiative. The Headquarters management function enable the entire Office of Energy Efficiency and Renewable Energy to meet its mission more effectively through corporate planning, execution, evaluation and improved customer service.

Conclusion

Mr. Chairman, we believe that our broad of range of programs offer enormous benefits to our citizens and to our nation and with continued support will continue to enrich the lives of future generations. Thank you for your continuing leadership and support in this areas of critical and enormous potential.

Chairman ROHRABACHER. Thank you very much. Mr. Li.

STATEMENT OF ALLEN LI, ASSOCIATE DIRECTOR, ENERGY, RESOURCES, AND SCIENCE ISSUES, RESOURCES, COMMUNITY, AND ECONOMIC DEVELOPMENT DIVISION, U.S. GENERAL ACCOUNTING OFFICE

Mr. LI. I feel like—Mr. Chairman, I feel like more of a marked man. And, I know how Mr. Largent felt when he was going down those long patterns and getting the ball thrown to him. But, I will try to do my best.

Chairman ROHRABACHER. Just don't fumble it now, you know.

[Laughter.]

Mr. LI. Mr. Chairman and members of the Subcommittee, I am pleased to be here today to discuss the results of our review of the Department of Energy's "Success Stories" report. As requested, I will be brief and focus my examples on energy efficiency and renewable energy technologies.

My written statement provides greater details on our review. First, some scene-setting.

In response to concerns raised about the effectiveness of its applied R&D programs, DOE published its "Success Stories" in May of 1995. The report described 61 technologies that were developed or supported by DOE's applied R&D program. The report highlights how each technology resulted in measurable economic benefits, such as energy savings.

Last Monday, we issued a report to Chairman Kasich that analyzed DOE's document. We focused on 15 of the 61 cases. The 15 cases we selected accounted for a substantial portion of the total benefits identified by the report.

In summary, our report makes two points: Point one: While "Success Stories" makes some valid claims about the benefits of DOE's applied research, we also found problems and incomplete analysis in DOE's supporting documentation.

However, I must note that although these problems caused us to question the amount of benefits claimed, substantial benefits may still be possible. Also, we focused on the analysis supporting DOE's derivation of benefits, not on establishing whether any individual case was a success.

Some examples to illustrate this first point. On the positive side, where there was adequate support, there is the DOE-2 computer software program. The software program calculates hourly building energy use. It has saved almost $2 billion in energy costs for buildings constructed through 1993.

Also, on the positive side, the high efficiency refrigerator compressor many of us have in our homes was made possible by DOE's sponsorship of an R&D project in the late 1970s.

But, our report also found instances where we feel the economic analysis was weak. For example, while discussing nickel metal hydride batteries, DOE claimed that mandates for electric vehicles in California and northeastern states will create a $350 million market for this battery in the year 2003.

The $350 million figure was derived by DOE assuming a battery cost of $7,500. However, automakers believe that a battery costing this much would not be marketable unless subsidized.

DOE support does not discuss the possibility of such subsidies.

The following is an example of where we felt the economic analysis was incomplete. We agree that energy savings have been achieved through the use of advanced energy efficient windows. We have a prop here. One of the witnesses that follows me will be showing you that.

However, we noted that DOE's analysis did not consider the added cost of these windows over traditional windows. As a result, net consumer savings will occur later than the time period used by DOE.

We found instances where the benefits did not result from the technology. In its discussion of the benefits of the AC electric drive, "Success Stories" cites a California mandate that is expected to create a $350 million market for electric vehicles.

We were told by an official with the California Air Resources Board that this mandate was developed independently of the AC electric drive. Although the drive train may help automakers meet the mandate by improving the performance of electric vehicles, its development did not result in the mandate.

Furthermore, it is worth noting that the presence of a market is only part of the story. Successfully meeting that market with a cost-effective product that consumers will buy is the other part.

Point Two. While "Success Stories" shows that DOE's applied R&D programs do produce some benefits, we believe it cannot be used to assess the effectiveness of DOE's entire applied research program. We continue to believe that this report is limited to describing the successes of a very small percentage of the projects funded.

In addition, "Success Stories" does not quantify the overall investment made by DOE to support these technologies. Some programs have required substantial funding.

A comparison of costs and benefits is a critical input in determining whether the agency's applied energy R&D program is of value and is properly focused. The Secretary's own task force on strategic energy R&D—and we just heard about the Yergin Task Force—they seem to agree.

In its June 1995 recommendation to DOE to develop an integrated strategic plan for energy R&D, they said. "Federal R&D programs should be based and prioritized on the systematic application of measurable cost benefit criteria tied to strategic economic or national goals."

In closing, we believe that the usefulness of reports such as "Success Stories" is primarily in providing examples of beneficial technologies that stem from DOE's R&D, not in establishing the basis for determining the value of the agency's entire R&D program.

Mr. Chairman, this concludes my remarks. I will answer any questions after the panel is finished.

Thank you.

[The prepared statement of Mr. Li follows:]

United States General Accounting Office

GAO

Testimony

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Committee on Science, House of Representatives

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ENERGY R&D

Observations on DOE's Success Stories Report

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Energy, Resources, and Science Issues,
Resources, Community, and Economic
Development Division

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Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the results of our review of the Department of Energy's (DOE) report, Success Stories: The Energy Mission in the Market Place. As you know, DOE's applied research and development (R&D) programs are designed to support the development of technologies that accomplish the nation's energy objectives, such as securing future energy supplies. In fiscal year 1995, DOE received appropriations of about $1.65 billion--almost 10 percent of its total budget--to spend on applied R&D programs. Some Members of Congress and the Congressional Budget Office (CBO) have questioned whether the federal investment in these programs is cost-effective.

In May 1995, DOE published its Success Stories report to respond to these concerns. The report briefly describes 61 technologies that were developed or supported by DOE's applied R&D programs. The report highlights how each technology resulted in measurable economic benefits, such as energy savings. Earlier this week, we issued a report to the Chairman of the House Committee on the Budget that focuses on whether (1) the claims DOE makes in the report are valid and (2) Success Stories can be used to assess the value of DOE's applied R&D programs.[1]

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[1] DOE's Success Stories Report (GAO/RCED-120R, Apr. 15, 1996).

In summary, Mr. Chairman, our review showed the following:

-- Although Success Stories makes some valid claims about the benefits of DOE's applied research, we found problems with the analyses DOE used to support the benefits cited in 11 out of the 15 cases we reviewed. These problems include basic math errors; problems in the supporting economic analyses, such as weak assumptions; and unsupported links between the benefits cited and DOE's role or the technology. These problems make DOE's estimates of the benefits for these cases questionable.

-- While Success Stories shows that DOE's applied R&D programs do produce some benefits, we do not believe the report can be used to assess the effectiveness of DOE's applied research programs overall because it only describes the "successes" of a very small percentage of the projects DOE has funded. In addition, Success Stories does not report how much DOE spent to support any of the technologies we evaluated. Without a comparison of costs and benefits, the success of DOE's applied energy R&D programs cannot be determined.

Before discussing these issues in more detail, we would like to provide some background information on DOE's Success Stories report.

BACKGROUND

For many years, DOE has devoted significant resources to energy R&D. From fiscal year 1978 through fiscal year 1993--the last year for which actual spending data are available--DOE spent $45.5 billion on R&D.[2] In fiscal year 1993, DOE provided almost one out of every two dollars spent in the United States on energy research. DOE received appropriations of about $2.37 billion in fiscal year 1995 for its research programs. Since the mid-1980s, DOE has dedicated about 70 percent of its total R&D spending to applied research, which develops scientific knowledge that has specific commercial applications.[3] DOE has also invested significant amounts in basic research. Basic research is directed at increasing the understanding of energy phenomena without regard for immediate commercial objectives. In fiscal year 1995, DOE received appropriations of $726 million for basic research in such areas as materials and chemical sciences.

Concerns have been raised about DOE's research and development activities. For instance, some critics maintain that applied research should be performed by the private sector, not the government. Also, in a 1994 report,[4] CBO contended that few successful technologies have emerged as a result of DOE's applied R&D programs.

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[2] Figures are in 1994 dollars.

[3] To estimate DOE's spending, we obtained DOE's historical budget data, then applied the budget categories for basic and applied research developed by the Secretary of Energy Advisory Board's Task Force on Strategic Energy Research and Development.

In response to such criticism, DOE produced its Success Stories report. In developing this report, DOE's Office of Science Policy first asked its applied research program offices to provide examples of technologies they had developed that produced quantifiable benefits. Officials from this office then chose what they considered the best examples to include in the report on the basis of the significance of the R&D in terms of DOE's mission, quantifiable measures of its impact, and other factors. They also selected cases that illustrate the range of DOE's applied research programs.

The resulting Success Stories report provides brief case studies of 61 technologies that were developed or otherwise supported by DOE's applied R&D programs. The cases presented in the report vary greatly according to the size and type of the research project, the types of benefits attributed to the project, the time at which the benefits occur, and the sophistication of the methods DOE used to estimate the benefits. For example, some describe relatively small DOE R&D projects that were completed years ago, while others discuss multimillion dollar efforts still under way, such as DOE's photovoltaic program, which has been directed at developing ways to convert solar energy into electricity since the 1970s.

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[4] Reducing the Deficit: Spending and Revenue Options, Congressional Budget Office, Mar. 1994. CBO's February 1995 report on the same subject no longer states that few successful technologies have emerged from DOE's applied R&D programs. However, the report states that many lawmakers have questioned the value to the economy of those R&D programs.

In describing the economic benefits attributable to the technologies, some case studies cite how a technology has conserved energy, cut production costs, or increased energy supplies, while others attribute increased exports or environmental benefits to the new technology. Similarly, the cases differ in the time frames in which the estimated benefits are achieved. Some cases estimate benefits that have accrued for one year, some estimate benefits throughout the 1980s and early 1990s, and others project benefits that will not occur before 2000 for recent or ongoing R&D efforts. In addition, DOE used different approaches or methodologies to estimate the benefits. In some cases, the analyses supporting the examples use market models or other sophisticated techniques, while in other cases the analyses rely on other approaches, such as a review of available sales data or an expert's best judgment about future markets.

To address questions about DOE's report, we evaluated the support for the benefits claimed for 15 of the 61 cases. The 15 case studies we selected for detailed review (1) covered all major program areas and fuel sources and (2) accounted for most of the large economic benefits identified by the report.[5]

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[5] Because the case studies were not consistently prepared and because we did not select a random sample, we cannot quantitatively generalize from our sample of 15 to the 46 other technologies described in Success Stories.

REPORT CITES SUPPORTABLE BENEFITS BUT CONTAINS MANY WEAKNESSES

Success Stories contains supportable claims for some of the benefits of DOE's research. For example, the atmospheric fluidized-bed coal combustor developed by DOE allows utilities to efficiently produce electricity from low-grade coal. DOE also documented its claim that DOE-2, a computer software program that helps reduce energy use in buildings, saved almost $2 billion in energy costs for buildings constructed through 1993.

However, we found problems with the analyses supporting the benefits cited for 11 of the 15 cases we reviewed. Although these problems cause us to question the amount of benefits claimed for these cases, substantial benefits may still be attributable to some of these cases. The problems we identified in the 15 cases fell into the following four general categories:

-- Math Errors. Two of the case studies were based on analyses containing basic math errors that greatly affected the estimates of the benefits. For example, the supporting analysis for the benefits of the carbon dioxide sand fracture production technology--a new process that is expected to increase production from some gas wells--improperly applied the price of natural gas to an incorrect amount of expected increased production. This error resulted in an unrealistic estimate of the increased revenues that could be expected from each well using the new technology. Applying the price of gas to the correct amount of expected increased production from the test wells over their first 7 years of production leads to an estimate of increased revenues of between $216,000 and $294,000 per well--not the $20 million per well cited in Success Stories.[6]

-- Problems with the supporting economic analysis. Nine of the 15 cases include estimates of benefits that are based on analyses containing weak economic reasoning, poor assumptions, or other errors. For example, when DOE projected the domestic sales of its integrated gasification combined cycle (a clean coal technology) from 1998 to 2030, it did not discount the sales figures to reflect the time value of money. Using a conservative interest rate, discounting would reduce DOE's claimed benefit from $150 billion to $44 billion. In another example, the supporting analysis for the mud-pulse telemetry project--a well-drilling technology developed by DOE that saves time and money--assumes that the total amount of money that the well-drilling industry has spent to purchase this technology equals the amount saved by the industry. This assumption incorrectly implies that every dollar spent on the technology is a savings attributable to the technology. The value of this technology to the industry is the amount of money the industry has saved by using it, rather that the amount of money the industry has spent on it.

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[6] In this case, DOE also incorrectly assumed that the technology would increase production throughout the productive life of each well. However, the supporting documents provided to us by DOE indicate that the scientists and engineers conducting the project are not willing to assume that the wells will continue to produce at increased rates past the first 7 years of the project.

-- Weak or indirect link between the stated benefits and DOE's R&D activities. Although DOE claims in Success Stories that it developed the carbon dioxide sand fracture technology, the supporting documents provided to us state that the process was developed and patented in Canada. DOE is currently demonstrating the effectiveness of the process on a number of U.S. wells. In another case, DOE cites that the flame retention head oil burner technology has saved $5 billion over the past 15 years, although DOE's contribution was limited to testing and publicizing the technology. Although Success Stories makes it clear that DOE's role was limited, readers could be led to believe that the value of DOE's contribution is the estimate of the total energy savings for the technology. We do not believe that the total savings resulting from consumers' use of this technology should be linked directly to DOE's activities.

-- Benefits did not result from the technology. In its discussion of the benefits of the AC electric drive train, Success Stories cites a California mandate for electric vehicles that is expected to create a $350 million market in 2003. However, according to an official with the California Air Resources Board, the mandate was developed independently of the AC electric drive train.

Although the drive train may help automakers meet the mandate by improving the performance of electric vehicles, its development did not result in the mandate. Thus, the potential market created by the mandate cannot be considered a result of the drive train.

REPORT CANNOT BE USED TO ASSESS THE VALUE OF DOE'S APPLIED R&D PROGRAMS

In our opinion, Success Stories cannot be used to assess the effectiveness of DOE's applied R&D programs overall for two reasons. First, none of the case studies we evaluated discuss how much DOE has spent on its R&D efforts supporting the technology. Such information is necessary to determine whether DOE's investment in applied R&D programs is cost-effective. For example, in describing the environmental advantages of the nuclear light-water reactor technology and the savings that will result if the operating licenses of current plants are extended, DOE does not mention that it has spent about $1 billion over the past 10 years on efforts to improve and advance the use of nuclear light-water reactor technology. DOE also does not discuss the environmental downside of nuclear power--the unresolved problem of long-term disposal of the high-level radioactive waste created by the reactors.

Secondly, we believe that the report cannot be used to evaluate DOE's applied R&D programs because it highlights only a small percentage of the projects funded by these programs and describes only what DOE considers to be the most successful of the technologies the Department has supported. The cases summarized in Success Stories are not a representative sample that can be used to evaluate DOE's applied R&D programs overall.

OBSERVATIONS

Assessing the effectiveness of DOE's total R&D programs is complex and important. In our opinion, DOE's report reflects the challenges decisionmakers face in trying to assess the effectiveness of federal R&D. We believe that the value of Success Stories in assessing federal investments in applied R&D is limited because it focuses solely on benefits and ignores the larger issue of whether DOE's applied R&D programs are cost-effective. DOE's applied research programs cannot be fairly evaluated on the basis of whether the Department can find several examples of success stories out of the thousands of projects funded under its programs. In our view, an objective evaluation would include an assessment of a representative sample of DOE's applied research projects that identified all relative costs and benefits and then used reasonable criteria to determine if funding these projects is cost-effective.

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Mr. Chairman, this concludes our prepared remarks. We would be happy to answer any questions you may have.

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Chairman ROHRABACHER. Thank you, Mr. Li. Mr. Nemtzow.

STATEMENT OF DAVID M. NEMTZOW, PRESIDENT OF THE ALLIANCE TO SAVE ENERGY, WASHINGTON, DC

Mr. NEMTZOW. Thank you, Mr. Chairman. I am here today to demonstrate, not to theorize, on the window of opportunity, literally a window, that is available for all of us.

I am David Nemtzow, President of the Alliance to Save Energy. We are a bipartisan coalition.

We are chaired by Senator Jeff Bingaman and count John Edward Porter, your colleague, among our co-chairmen. We have 85 companies we work with day in and day out to promote our shared mission of energy efficiency.

I would like to submit my entire statement for the record and focus on four key points about energy efficiency. And, I would say while the Alliance only works on energy efficiency, the same points, I think, are valid in your Committee's debate about renewable energy.

The first point I would like to make is that the research, development and deployment of clean energy sources, such as efficiency and renewables, serve a multitude of essential national priorities. This has two consequences for this Committee.

The first is your contribution to these essential national priorities. We have heard about energy security.

We have passed a very dangerous mark. We now import more oil than we produce in this country.

You know about the priority of environmental protection. Ninety percent of air pollutants created every year in this country are from the production and consumption of energy.

You know about the economic health as our nation tries to become more competitive worldwide. Two million new jobs can be created through a high efficiency strategy, helping U.S. firms meet an $84 billion worldwide market for clean energy technologies.

It's also important to talk about the issue of basic versus applied research versus deployment. I believe that there is a single spectrum that the function of government is to help promote these technologies.

And, that takes many activities. There is no point in having a brilliant science that sits on the lab bench. If it doesn't get through deployment, if it doesn't get into people's hands, if it isn't used, then it's not helpful.

And, I think the research agenda should reflect all those essential national purposes.

The second point I would like to make today is that these programs, if done right—and I think they are—are not corporate welfare. There has been a debate about corporate welfare.

Corporate welfare, to me, implies, like any form of welfare, a check, an entitlement you get every month whether you deserve it or not. That's not what these programs are.

What they are are partnerships between the public sector and the private sector. They are contracts to help provide research, to use the government research power at the labs, to work with companies to get that into the marketplace.

At the Alliance to Save Energy, we believe strongly in public/private partnerships. I think this is a perfect example.

The third point I would like to make today is that energy efficiency is a key environmental strategy. The Congress is working hard to reinvent environmental protection.

To think about how you can promote environmental protection in a non-regulatory fashion in a way that is most cost-effective, there is no better answer for you than energy efficiency. Energy efficiency programs tend not to be regulatory.

They tend to be voluntary and technology-based. And, most important, they are pro-economic growth.

They don't cost money. They save money. It lets you do environmental protection and economic growth, which is exactly why a new poll shows that the American public overwhelmingly support efficiency and renewables as the key priority for federal research spending.

Over 55 percent of the public think efficiency and renewables should be the Number One research expenditure. No other energy source even crossed the 10 percent mark.

The fourth point I would like to make for the Committee is that the Department of Energy and Assistant Secretary Ervin's operation has been doing the job. They deserve your continued support.

I know we will have a discussion today about their successes and how big they are. But, as we just heard from the GAO and from Assistant Secretary Ervin, there are successes.

We have a debate about the methodology and the exact quantity. But, I don't think anybody debates that there aren't successes.

I would like to bring this point home, literally home, and show you one of these successes. Mr. Chairman, this is a "low-E" window that you heard about. And, I have another one if you want to see it close up.

This window is made by Anderson and this one by Pallid. They are made by all of the manufacturers.

These windows—this is—it doesn't look—it looks like a normal window. It's supposed to. It's a high-tech window of the future.

And, it wouldn't be here but for the Department of Energy as well as the Lawrence Berkeley Lab. In fact, the DOE official you quoted earlier, Mr. Chairman, David Pellish, was the program manager for this. And, he did work at Tufts University in Mr. Olver's home state that helped develop this technology with Lawrence Berkeley Lab.

What is it? It's a thin film sandwiched between the glass windows here that blocks the heat loss, so that this window with this thin film—and it's also filled with an inert gas, argon gas—act as an insulator.

Now, for the people who have to use this everyday, it's a perfect window. It's a great window.

You have great views. But, it saves energy.

This window performs as well in conserving energy as a typical wall does. And, you would never know it.

And, that's the kind of product we need. DOE was essential in bringing this window to the marketplace.

Was DOE the only player? Absolutely not. It couldn't happen without the private sector.

Would it have happened without DOE? No, it wouldn't, Mr. Chairman. And, it certainly wouldn't happen in a timely fashion.

Chairman ROHRABACHER. You are done with your time right now. Maybe just a couple of questions to get your window out of the way here.

Mr. NEMTZOW. Absolutely.

Chairman ROHRABACHER. What—that's on the market now?

Mr. NEMTZOW. It is. You can purchase it today. In fact, there's a labeling system. I don't know if you can see it.

Chairman ROHRABACHER. All right. And, how much does it cost?

Mr. NEMTZOW. This window probably costs the same as a regular double-glazed, two-pane window. The film is inserted.

It's quite cheap at this point in time. There used to be a bigger cost differential. That is decreasing over time.

Chairman ROHRABACHER. Okay. So, the R&D was done by the Department of Energy and now this window is available on the market?

Mr. NEMTZOW. That's right. And, now the Department of Energy's programs are looking at the next generation, things called electric chromic windows, the super high-tech windows for the next generation to save on bills.

This window, by the way, Mr. Chairman, is perfect for your district in southern California. It's designed to prevent air conditioning loss in the summer. It's for sunny climates.

Chairman ROHRABACHER. Maybe you could give us one estimate of the value of that in terms of energy savings.

Mr. NEMTZOW. So far, these windows have contributed $1.8 billion in energy savings. And, that's so far.

These windows are going to stay in the homes for decades to come and keep producing savings for many years to come. But, so far, we are already up to $1.8 billion.

And, we have already avoided the production of seven million tons of carbon dioxide, thanks to these high-tech windows. They are a great product.

And, I encourage you to support them.

Mr. ROEMER. Mr. Chairman——

Chairman ROHRABACHER. Would you like to ask——

Mr. ROEMER. Is there any way we can enter that into the record? [Laughter.]

Chairman ROHRABACHER. All right. I'm trying to think of some pun, but I can't do it right now. Something about the windows of opportunity here.

Mr. NEMTZOW. You can keep that one. Just in conclusion, I would just like to say for Mr. Roemer, I could talk about flame retention burners, another DOE technology.

They make them in his district, in Indiana. They help homes use less oil to heat the home.

There's so many—there isn't a room big enough in the Rayburn Building, frankly, to wheel in all the props from DOE's success stories over the years. They have won an arms-length worth of awards for their research.

It's very commendable. This is one of the many products. There are many others that I would be happy to talk about.

In conclusion, I would just like to say that I thank you for holding this hearing. And, we are really counting on you.

We really believe that you have a wonderful opportunity here to promote environmental protection, promote economic growth. We would like to stand by you a year from now at a press conference when you and the other members of the Subcommittee and Committee can take credit for your vision in supporting this research agenda.

Thank you very much.

[The prepared statement of Mr. Nemtzow follows:]

TESTIMONY OF DAVID M. NEMTZOW
PRESIDENT OF THE ALLIANCE TO SAVE ENERGY
BEFORE THE HOUSE SCIENCE COMMITTEE
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
REGARDING THE FISCAL YEAR 1997
BUDGET FOR THE DEPARTMENT OF ENERGY'S
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

APRIL 17, 1996

Good afternoon Mr. Chairman. Thank you very much for inviting me to testify before you today regarding the budget for the Department of Energy's energy efficiency and renewable energy programs.

My name is David Nemtzow and I am the President of the Alliance to Save Energy. The Alliance is a bi-partisan, non-profit coalition of business, government, environmental, and consumer leaders dedicated to improving the efficiency with which our economy uses energy. The Alliance was founded in 1977 by Senators Charles Percy and Hubert Humphrey; it is currently chaired by Senators Jeff Bingaman and James Jeffords as well as your colleagues, Representatives John Edward Porter and Ed Markey. The Alliance works with 85 Associate companies which include the nation's leading energy efficiency firms, electric and gas utilities, and other companies committed to cutting their energy bills.

I appreciate this opportunity to speak to the Subcommittee about energy efficiency programs at the Department of Energy. Mr. Chairman, I want to make four points while I am here which together make a case for continuing strong initiatives to create, develop, and deploy energy efficiency and renewable energy technologies. The Alliance to Save Energy works exclusively on efficiency technologies and issues; therefore the examples I use will focus primarily on the efficiency side of the equation. Each of the essential principles below, however, applies fully to renewable energy as well. They are:

1). Applied research toward developing clean energy technologies is an absolutely appropriate and worthwhile function of the federal government because of the broad array of national interests which would not happen without such efforts;

2). Federal and State partnerships with the private sector do not constitute "corporate welfare" if and when the cooperative efforts exist not to fatten corporate pockets, but to effectively pursue national interests;

3). Research, development, and deployment of energy-efficient technologies -- moreover, voluntary programs which catalyze the private sector -- is a positive environmental strategy which, for a relatively small investment, seeks to keep the U.S. ahead of the need for additional "command and control" environmental regulation;

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4). Past successes on the part of D.O.E.'s Office of Energy Efficiency and Renewable Energy, in cooperation with the national laboratories and the private sector, justify continuation of and strong support for these programs. In short, they do produce valuable results and are a prudent investment for the American taxpayer.

I would like to elaborate on these four principles, focusing especially on the first one.

PRINCIPLE 1.
RESEARCH AND DEVELOPMENT OF CLEAN ENERGY SOURCES SERVES AS AN ESSENTIAL NATIONAL PRIORITY

The energy crises of the 1970s illustrated the danger to our national security, economy, and well-being from economic dependence on politically unstable supplies of energy. Expensive and scarce petroleum for heating and transportation sent the country into a frantic search for new domestic energy sources. They also triggered recessions that inflicted considerable economic pain on the nation. Those shortages prompted aggressive research efforts by the newly-formed Department of Energy to maximize the energy efficiency of our economy while seeking to harness renewable energy from the sun, wind, earth, oceans, and other sources.

Some observers now argue that cheap and plentiful oil has removed the need for federal research into clean energy sources -- that if efficiency and renewables are economically desirable they will be provided by the private sector. They contend that seeking technological breakthroughs in energy is a luxury that we cannot afford in a time of tight money and pursuit of a balanced federal budget.

Mr. Chairman, this assessment might only be right if one ignores the varied and crucial national interests which are served by a cleaner, more efficient economy and a nation which can provide new, clean technologies to a rapidly developing worldwide economy. In fact, Mr. Chairman, now is the most crucial time to aggressively pursue energy efficiency and renewable energy research and development.

A. Energy Efficiency Promotes Environmental Health, Economic Growth, and National Security

As an underlying principle of capitalism, efficiency is a concept which is rightfully lauded by our society. We admire the more efficient entrepreneur, who puts out a product for the least cost and makes the most money. However, when applied to energy in a world of environmental degradation, global economic competition, political instability in energy-exporting areas, and an uncertain employment future for our nation's children, energy efficiency can no longer be looked at in the simple terms of economics.

The benefits of energy efficiency are broad and diverse, with huge potential for supporting crucial national political, economic, security, and environmental concerns.

Environmental Health
The most polluting activity on earth is the production, transportation, and use of energy. Electricity generation, vehicle exhaust, oil spills, the heating and cooling of buildings, industrial processes, and myriad other uses of energy account for what is estimated to be 80-90 percent of environmental pollution in this country. As our population and economic activity increases into the 21st Century, environmental stresses on our air water and land will be heightened.

Energy efficiency can be a huge source of environmental benefit by reducing energy inputs which go into a unit of output. Utilizing energy efficiency measures prevents pollution, reducing the need for "command and control" regulation which can be costly and inflexible for companies seeking to comply with the law.

DOE's Office of Building Technologies can claim credit for significant pollution prevention through the development of a variety of technologies which have significantly reduced energy use in buildings. Lawrence Berkeley Laboratory's contribution to the development of electronic lighting ballasts for use with fluorescent lamps is a good example of how DOE served as a catalyst to expedite and support sustained progress on a product with immense energy saving and pollution prevention potential. A recent analysis by the American Council for an Energy-Efficient Economy shows that electronic ballasts, which now account for over 30 percent of ballasts produced and sold in the U.S., have, as of 1995, displaced 44,000 metric tons of acid rain-causing sulfur dioxide, 33,000 metric tons of urban smog-causing nitrogen oxides (NOx), and 7.1 million metric tons of carbon dioxide annually.

A variety of technologies developed by or with the assistance of DOE's Office of Industrial Technologies (OIT) have enabled industries to reduce pollution, the cost of waste disposal, and the cost of compliance with environmental statutes. For example, DOE brought Praxair, Inc., Corning, Inc., and Gallo Glass Co. together to explore the practicality of using pure oxygen in glass furnace combustion. The goal was to save energy and reduce the high levels of nitrogen oxide (NOx) emissions caused by the standard process. The results of this effort produced a combustion process in which NOx is reduced by 90 percent, fuel consumption is cut by 25 percent, and cost savings result from simplified furnace equipment. One glass-maker was able to save several hundred jobs by adopting the process, and reducing pollution costs, thus averting a plant relocation.

Domestic Economic Growth, Consumer Savings, and Job Creation
While I stated earlier that the purely economic view of efficiency is too narrow a criteria to measure energy efficiency, it also should not be ignored. Energy efficiency makes money and puts people to work. Federal and private energy efficiency measures have encouraged our economy to grow by 70 percent between 1973 and 1996, while our energy use grew by just 20 percent over that period. **The Alliance estimates that had our level of efficiency remained at 1973 levels, we would now be spending over $125 billion more for our energy bills each year.**

The economic gains from energy efficiency come in two forms. The greatest benefit comes form displaced costs -- money that households and businesses can spend elsewhere because they no longer have to spend it on energy. That spending includes additional investment and hiring

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additional workers. The more than $125/100 billion annual energy bill savings provides significant economic health to the nation. Direct economic benefits come from growth in industries which generate energy-efficient products and services. Companies which sell insulation or efficient windows domestically and/or for export employ Americans in high-skill service and manufacturing jobs. Secondary economic benefits come from businesses and consumers re-spending these newfound energy savings in sectors of the economy which are more labor-intensive than energy supply.

Increased productivity through energy efficiency increases can be a vigorous engine for job creation in local economies. A new study entitled *Colorado's Energy Future: Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy* produced by Economic Research Associates, Inc., finds that with a $4.1 billion investment between 1995 and 2010, Colorado could reduce its energy use by 30 percent below 1988 levels. These improvements would create 8,400 jobs and a $7.9 billion gross and $3.8 billion net benefit for the Colorado economy. In addition, the study found that the cost of living for a family of four would go down an average of $268 per year.

DOE's role in the development of low-emissivity window coatings illustrates the economic benefits which accrue throughout the economy with the creation and adoption of energy-efficient products. Work at Lawrence Berkeley Laboratories on these "low-E" windows began in 1976, working with coatings which were then beyond the scientific capabilities of window manufacturers. These efforts resulted in the introduction of the product into the marketplace in the early 1980s. Through the 1980s LBL continued to test new products, provide valuable design tools to the fenestration industry and spur additional improvements and market penetration for efficient windows, helping to bring them to where they are today. By 1988-89, about 28 percent of purchased residential windows and 15 percent of commercial windows contained low-E coatings. This rose to 32 percent for residential windows in 1993. In new construction alone, this figure rises to 40 percent, demonstrating how much home builders value low-E products.

During the past twenty years, DOE invested approximately $20 million in low-E windows. Calculated by ACEEE, this technology has resulted in additional revenues to manufacturers of roughly $2 billion. Add to that the $2 billion which is accruing to owners of efficient windows in the form of energy savings. As the technology continues to improve and cost premiums continue to drop, market share is expected to rise adding steadily to the level of economic benefits of the technology.

To illustrate the employment benefits derived from low-E windows, a group of 20 California-based window manufacturers wrote in a letter to the California Energy Commission in 1994, stating that:

> "Higher performance windows will increase net employment in California by creating new jobs. Our current total employment is 2,810 California employees. The production of higher performance windows is generally more labor-intensive than lower performance windows. We estimate that this number will increase by 37 percent to 3,850 California employees by July, 1994, as a result of [proposed

standards that would encourage the use of low-E windows]."

DOE's efforts have certainly helped California businesses like Southwall Technologies and Airco get started in this business. Today DOE continues to provide value to consumers by exploring low-E windows designed to reduce cooling loads, by supporting the National Fenestration Rating Council to certify and label the performance of windows, and by promoting the use of WINDOW software as a design tool to further expand the market for high performance windows.

National Security

As the Persian Gulf War is discussed by contemporary historians, one rarely hears about the "naked aggression" which was cited by President Bush as the primary reason for our involvement. More often it is simply acknowledged that the U.S. went to war with Iraq in 1991 to defend its critical oil interests in the region. When considered by economists, the billions which American taxpayers shelled out to protect those interests should be added not onto our military or diplomatic budget, but onto our national expenditure for energy.

The U.S. has now crossed the line of being dependent for more than half of its oil consumption on foreign sources. Two-thirds of that habit comes from transportation. That situation will grow significantly worse in the coming decades for two reasons. One, U.S. consumption will continue to grow both in the number of vehicles on the road and the amount driven by each one. Two, the concentration of remaining global oil reserves will grow more consolidated in the Persian Gulf region as time goes on, making the U.S. more and more beholden to a region which demonstrates its volatility nearly every day. Consequently, U.S. dependence on foreign oil is projected to rise to nearly 60 percent within 10 years.

The Partnership for a New Generation of Vehicles program of the Office of Transportation Technologies is working to develop a prototype six passenger sedan which gets 80 miles per gallon, which will run 80 percent cleaner than current vehicles, and which does not result in less safety, greater cost, or reduced performance. Only through significantly improved fuel economy and auto emissions can we offset the increase in driving expected for the next 25 years. In light of political opposition to increased Corporate Average Fuel Economy (CAFE) standards, we will not likely move any significant distance toward greater efficiency without continued federal initiative in research and development.

Global Economic Development and Competition

Burgeoning economic development throughout the world presents massive opportunities for American business to parlay its technological leadership into economic gain. As massive populations such as India and China move to develop their economies and their energy resources, they will make decisions and purchases in the next few years which will provide the infrastructure for that development. The method in which it occurs will have profound effects on the global economy and environment.

The estimated potential of the global market for energy efficiency products and services over the next 10-15 years is $84 billion. All Americans want to see the fulfillment of a large part of that market potential come back as U.S. jobs and revenue. However, U.S. exporters face strong competition from a variety of nations in energy technologies, many of which give aggressive R&D and international marketing assistance to native businesses. For example, the U.S. government now spends less on research and development than the Japanese government -- not less per capita, less outright.

Mr. Chairman, now is not the time to back away from technological investment which can significantly contribute to our nation's future economic growth and ability to compete in international markets. In addition, as global environmental concerns become more and more key to our own quality of life, we must staunchly defend the technological leadership we now hold and be able to provide environmentally sound technologies to the developing world.

B. Public Opinion Supports Clean Energy R&D

Mr. Chairman, five months ago, the Alliance and other organizations commissioned a survey conducted by Republican pollster Dr. Vince Breglio's Research/Strategy/Management, Inc. to measure public attitudes about energy R&D priorities. The results came out loud and clear. Renewable energy or energy efficiency programs were the top priorities of 55.1 percent of the registered voters surveyed. (No other category of energy source exceeded 10 percent support.) This strong support was approximately equal for Republicans, Democrats, and Independents. Conversely, efficiency and renewables trailed far behind nuclear and fossil fuel programs when respondents were asked their top priorities for cuts. The salience of the issue was demonstrated when 53.7 percent of voters expressed that they would be at least somewhat more likely to vote for a candidate who shares their priorities on these issues.

C. Applied Research "vs." Basic Research

Mr. Chairman, there has been much discussion over the past 16 months in your Committee of the distinction between basic science research and applied science research, and the proper role for government in dealing with each. Mr. Chairman, I believe that the Committee is looking in the wrong place for a point at which to draw a line between an acceptable and unacceptable government role. The determination of what research should be carried out should not be a debate over whether the research deals with chemical and physical properties rather than with technological development.

If you do draw the line at applied research, you partition off energy efficiency and renewable energy as they are technology-based. But doing that would detract from our nation's ability to achieve energy security, protecting the environment, and providing technology-based jobs for our economic future. In fact, current economic behavior demonstrates daily that none of these goals are the mission or a necessary outgrowth of private sector activity of the private sector. We must conduct federal research and development efforts according to the national interests which are served by them and whether those interests are fulfilled by the private sector -- or not.

D. Technology Deployment is Integral to a Successful Research Agenda

If we consider, for the moment, that the pursuit of national goals should be the most important criteria for allowable activities, then we must take up the question of whether technology deployment falls into the acceptable range of activities.

The need for having deployment in the toolbox of DOE is illustrated by the story of the flame retention oil burner. DOE did not develop this technology. However, in response to the oil price shocks of the 1970s, DOE worked with the oil heat industry to field test and promote the technology as a substantial energy-saver. The key was a program to train fuel oil technicians how to install these advanced burners to yield the most savings for homeowners.

The subsequent realization by the oil heat industry of its attributes created demand, and adoption of the flame retention head oil burner increased about ten-fold between 1979 and 1983. Now the technology is in use in about 7.3 million households, over half of oil-heated homes. The burner provides an 11-22 percent energy saving, Mr. Chairman, and a conservative energy savings estimate of nearly $7 billion for consumers from a simple, existing technology -- in large part due to deployment efforts by DOE. DOE's responsibility for this benefit can be traced to addressing barriers that were inhibiting wide use of the technology, and accelerating market penetration.

E. Clean Energy is Underfunded by Corporate R&D

Two major reports were released in 1995 which came to the same conclusion about forgoing research and development: if DOE research in energy technologies is eliminated, it will not be replaced in kind by the private sector. Both the Galvin Commission studying the national laboratories and DOE's Yergin Task Force have looked at energy research and development and arrived at this conclusion. Among the reasons they cited as barriers to corporate efforts are high R&D costs, internal cost-cutting which has resulted in widespread downsizing of companies, uncertainty of property rights and the ability to capture all the benefits of R&D, and high initial investment in R&D capability.

Most importantly, Mr. Chairman, the short-term, bottom line priorities of individual companies do not encompass the strategic national interests which I have cited above. Again, without research, development, and deployment efforts in these areas, these national needs will go unmet.

F. Standards for Acceptable Research, Development, and Deployment Efforts

Mr. Chairman, the need for a balanced budget means that the federal government should not be doing the work of the private sector. Projects seeking to qualify for federal dollars should adhere to strict guidelines. These include:

1). They must have significant potential benefits for the nation, as described above.

2). The level of technical difficulty and risk of the project is such that it will not be undertaken by the private sector on its own.

3). The structure and/or economics of the particular industry would prevent sufficient R&D spending.

4). A promising technology is sufficiently distant from the market, and whether competitive considerations would keep it from achieving exposure.

5). The project directly addresses the barriers that prevent technologies from taking root in the marketplace.

PRINCIPLE 2.
EE/RE'S PROGRAMS ARE NOT "CORPORATE WELFARE"

Mr. Chairman, much of the rhetoric criticizing EE/RE programs has centered on the idea that because DOE in many circumstances offers grants to the private sector to conduct research and development, that those funds constitute "corporate welfare." I don't mean to belabor the point, Mr. Chairman, but these voluntary partnerships with the private sector should be considered in the *"national welfare"* because they pursue the national interest rather than that of any specific industry or corporation.

"Corporate welfare" implies large, ongoing subsidies designed to keep an industry afloat, or perhaps preserve jobs in a politically sensitive area. As opposed to broad government subsidies, DOE's efficiency research grants are small, targeted expenditures which set out to accomplish a specific goal. The grants are generally for technology research or testing, producing or refining design tools and performance information, and confronting commercial barriers to the adoption of an energy-saving technology. In many cases, rather than benefiting a single firm, government involvement causes an energy-saving technology to be made accessible throughout an industry to obtain the maximum benefit for the economy and environment rather than it receiving proprietary use by one firm.

As EE/RE pursues cooperative projects with the private sector, it has a strong and improving record of leveraging significant funds from industry to accomplish its goals. DOE grants seek to serve a catalytic function, giving companies and entrepreneurs an incentive to focus on the energy-saving or pollution-preventing properties which would not otherwise be in their interest to exploit. In short, DOE grants provide a minimum motivation for companies to focus on the *national interest*, while opening possibilities for expanded technology and future revenue to which they would not otherwise assign weight.

PRINCIPLE 3.
ENERGY EFFICIENCY CAN BE THE CORNERSTONE OF AN EFFECTIVE, FLEXIBLE ENVIRONMENTAL AGENDA

Mr. Chairman, the Alliance to Save Energy has a long history of strongly supporting bi-partisan cooperation between government and the private sector to solve problems. We are well aware of and sympathetic to the concerns of business about often costly and inflexible "command and control" regulations. That is why we so strongly favor these voluntary programs which work with companies to make significant environmental gains.

I have recounted several examples of technologies and programs developed by EE/RE which have prevented literally millions of metric tons of pollutants from reaching our air, water, and land. These are a few examples which do not purport to catalogue the overall environmental benefit of energy efficiency and renewable energy programs. However, all of the environmental benefits which have been attained from these research and development efforts have been achieved without costly regulation. These are accomplishments which should be heralded, Mr. Chairman, by a Congressional majority which frowns on regulation and supports strong economic growth, yet takes the federal burden of environmental protection seriously.

If the Republican majority is to develop a positive environmental agenda, Mr. Chairman, it should be built around the benefits of clean energy sources.

Mr. Chairman, one quick word about global warming. The Intergovernmental Panel on Climate Change, a working group of over 2000 scientists worldwide has reported that global warming is occurring now and that many of the negative effects predicted for it are beginning to occur. In addition, the survey conducted by the Alliance and others five months ago told us that 70.9 percent of Americans now believe that global climate change is a serious problem.

Leaving aside, for a moment, an assessment of the validity of all of the IPCC claims, I believe a reasonable person would agree that there is at least cause for concern and further study. Mr. Chairman, would a prudent, conservative strategy on global warming not be to hedge against potential costly effects, such as coastal impacts from rising sea levels, by making a modest investment in voluntary programs to develop technologies which reduce emissions of greenhouse gases -- ones that also contribute to national economic growth, international competitiveness, and national security?

Again, Mr. Chairman, those in Congress who seek regulatory reform and flexibility for environmental compliance should establish energy efficiency and renewable energy programs as the bedrock of a positive environmental agenda.

PRINCIPLE 4.

D.O.E.'s OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY CAN DO THE JOB

Mr. Chairman, I am not here to argue that there have been no missteps in EE/RE programs. Any research and development -- whether done by the private or public sectors -- is inherently risky and successful technologies do not always result. However, I do firmly assert that the risk is justified by the national interests which this research and development supports. In addition, the successes -- some major and minor ones are cited here -- have benefited virtually every American, whether the CEO of a windows company, a job seeker in an economy which has more disposable income with which to employ her or him, or a homeowner who can take advantage of new high-performing products, or a resident of a city which has one more day in a year to breathe air which is in attainment with smog standards.

Mr. Chairman, the Alliance supports continued upgrading of research, development, deployment, and impact assessment methods to more effectively garner, more uniformly and accurately assess, and more easily convey the benefits of these programs. We can do better than to simply give up on additional billions in economic savings and prevention of pollution. I urge you and the other members of the Committee to help bring these efforts to a standard which facilitates a clear expression of pride in their achievement rather than reflexive skepticism about their value.

CONCLUSION: NEW SOLUTIONS FOR A NEW CENTURY

Mr. Chairman, federal research, development, and deployment of energy efficiency and renewable energy technologies serve our nation by protecting the environment, spurring domestic economic growth through increased productivity, enhancing exports, creating jobs, lowering energy costs for consumers, bolstering national security, and leveraging millions of private dollars to devote to public goals. Each of these is a critical need which is not adequately addressed by the market itself. DOE has been strikingly successful at helping small, medium, and large companies contribute to these national goals, while serving their own responsibilities to their shareholders, employees and others. While we agree that running a fiscally responsible government is essential, we can find few areas of federal investment which yield so many varied and essential benefits to the nation.

We also agree that DOE's efforts in these areas can continue to be improved and refined. However, proposals to significantly scale back or even eliminate clean energy research and development are not prudent for a nation striving to make its way into a new century where technology and innovation -- rather than reserves of finite natural resources -- will determine national wealth and well-being. As population growth and increased worldwide energy use stand to put ever greater stress on our environment and resources, it is crucial that the U.S. is not left behind other technologically capable nations in providing solutions.

Mr. Chairman, we respectfully urge you to work with the Department of Energy -- and with the Alliance to Save Energy -- to make these programs the best they can be. The national interests which are served by energy efficiency and renewable energy are bi-partisan and roundly endorsed by the American public. Let's work together to enhance our national success at achieving them.

Chairman ROHRABACHER. Well, thank you very much. We appreciate your testimony.

And, you have that piece of technology here. So, I thought it was important to give you an extra couple minutes so we can understand it.

Mr. McMahan.

STATEMENT OF DR. RONALD L. McMAHAN, PRESIDENT AND FOUNDER, RESOURCE DATA INTERNATIONAL, INCORPORATED, BOULDER, COLORADO

Dr. MCMAHAN. Thank you, Mr. Chairman. Mr. Chairman and members of the Subcommittee, I am pleased to be here today to summarize the findings of a recent study that my company conducted assessing some of the outlook for renewable and traditional energy resources in America's electric generation mix.

First of all, not all generating technologies are interchangeable. They have to all be evaluated relative to their cost, their environmental impacts and then the usability of the resource; in other words, its ability to provide power, when and as needed.

There's only seven ways really to generate electricity right now. Today, we are generating about three trillion kilowatt hours of electricity—55 percent from coal, 20 percent nuclear, gas 11, hydro 9, oil 3. Renewables generate about 2.

That's broken into what we consider to be two important subdivisions—combustion technologies and non-combustion. It's 70 percent or about 1.4 percent of all generation comes from combustion, biomass and only about .6 of 1 percent from wind and solar.

Relative to the cost, we have a chart that shows that on a levelized cost basis for a utility that is making investment decisions today, coal is by far the cheapest technology to install, then gas, then wind. But, remember that wind has some geographic and some capacity limitations.

Then, biomass which is about twice the cost of coal. But, some applications do offset industrial open air burning.

Then, finally solar is the most expensive.

Chairman ROHRABACHER. When you are saying that coal is the cheapest, is that coal that is installed in accordance with all of the Clean Air rules and——

Dr. MCMAHAN. Absolutely, yes. This is for—what we evaluated was new technologies that utilities have to choose from going forward.

Chairman ROHRABACHER. Right. So, even with the strict requirements that the energy producers would be operating under, coal would still be the cheapest to build a plant to produce a certain amount of electricity?

Dr. MCMAHAN. Absolutely. There is no question about that.

As far as the environmental considerations, looking forward, nuclear obviously has some big problems with public acceptance. Hydro is going to decline under the mandates of the Energy Policy Act, because we are going to lose capacity due to stream flows and those sorts of things. So, those aren't going to be new technologies, at least in the next 15 years.

On the renewable side, on the combustion side of the world, landfill gas is better than venting the methane obviously. Municipal solid waste has some serious toxicity problems and a lot of communities are beginning to shy away from that.

Biomass essentially is a combustion technology that has some land use questions and is really no better than fossil in terms of the emissions.

On the non-combustion side, photovoltaic is obviously non-emitting. But, there are some questions about land use and the chemical processes.

As far as wind power, the only major stumbling blocks are the wildlife issues and visibility and noise.

Coal, as you've stated, is well within the sulfur to oxide NOX particulates. CO2 continues to be an issue with coal and with gas.

There is another chart that illustrates, I think, what a lot of people don't realize. The 1970s version of a coal plant versus all of the coal plants and gas plants on the right side of that chart is that virtually all of the emission problems from SOX and NOX and particulates have been solved and are solvable under the current Clean Air Act amendments.

And, as far as the usability issues, capacitization tells you how much bang you get for the buck. Coal runs at about 85 percent capacity to utilization rate; gas, 65.

Combustion renewables run at about 50 percent. And, non-combustion renewables run at about—such as photovoltaic and wind run at about 10 to 25 percent of their capacity because of the availability.

As far as the outlook, we looked at three scenarios for how we think the future might unfold. Given the existing subsidies for renewable energy of about a penny and a half a kilowatt hour, we projected out through the year 2010, over a 15 year period, our base case shows the amount of renewable energy doubling in the U.S. from about 2 percent of the mix up to about 4 percent of the mix.

Now, there is a cost to that. If you look at the cost to a utility of installing one of these renewable technologies versus least cost technology, we calculate that that cost will be about $50 billion to the ratepayers, shareholders of the utility. Somebody will pay that differential in the cost from the previous graph.

Coal is going to garner most of the base load growth. And, gas is going to garner a tremendous amount of growth in the next few years.

We did also postulate a scenario under free and open competition where the utility industry is moving right now. And, under that situation, the market alone is going to dictate renewables in the market niche.

But, some trends are an indicator. For example, biomass in California, capacity in 1991 was about 880 megawatts. By 1994, it was down to 635.

The California Energy Commission projects by 2000, it will be down to 100. Why? Because of the high cost of generating electricity with biomass.

In Maine, Central Maine Power just bought out a biomass project for $76 million.

We also looked at a final scenario—I will be brief—in which we intensify the subsidies and get away from the differentials between the cost of coal and—of fossil and renewables. And, we saw that the technological limitations would see that only about an 11 percent market share is all that renewables would get but that that cost would get up to about $200 billion.

I know for people who deal in trillions that doesn't sound like a lot. But, effectively, that would replace the entire fossil plant in the United States of America.

Thank you.

[The prepared statement of Dr. McMahan follows:]

TESTIMONY OF RONALD L. MCMAHAN

Mr. Chairman, members of the Subcommittee, I am pleased to be here today to summarize the findings of a recent study my company conducted assessing the outlook for renewable and traditional energy resources in America's electric generation mix.

My name is Ronald L. McMahan, and I am President and founder of Resource Data International, Inc. in Boulder, CO. I am an energy economist, and my practice includes a) the maintenance and distribution of integrated market and competitor databases subscribed to by more than 200 clients ranging from private companies to government agencies, b) multi-client studies covering timely energy issues (e.g., Retail Power Markets, Transmission Markets, Mergers & Acquisitions, Coal Transportation, etc.), and c) a consulting practice. My firm publishes regular "market watch" columns in leading industry periodicals including *Public Utilities Fortnightly, Electric Light and Power*, and *Coal Magazine*, and we are often quoted and relied upon by publications such as *The Wall Street Journal, The Financial Times, Forbes*, and the wire services.

As background, in late 1994, RDI was contacted by The Center for Energy and Economic Development (CEED), and asked if we would consider conducting a study to evaluate the economic and environmental "pluses and minuses" of a broad range of electricity-generating technologies. RDI agreed to conduct the study on the condition that it would be an independent, objective analysis based upon the broadest possible set of inputs from the government, industry and research organizations based on current costs. The resulting study, *Energy Choices in a Competitive Era: The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix (Energy Choices)* has been submitted to the Subcommittee and the Executive Summary is attached to my prepared remarks.

OVERVIEW

U.S. electric utilities and non-utility generators annually produce about 3 trillion kilowatt hours of electricity from a mix of energy resources led by coal (55%), then by nuclear (20%), natural gas (11%), hydro (9%), and oil (3%). Non-hydro renewable energy sources including biomass, municipal solid waste, landfill gas, solar, wind and geothermal accounted for the remaining 2%. As the country moves forward, with electric demand growing by about 1.5 percent per year, new generating capacity must be added to the nation's fleet of power plants and choices will be made about which technologies to employ.

These choices will be based upon a number of factors. First, in a deregulating electricity utility environment, the primary factor affecting technology choice will be cost. Gone are the days when high-cost, inefficient generation projects can simply be forced into the rate-base with excess costs passed through to the rate-payers while "franchise monopoly" utilities maintain a fixed rate of return. In a new, competitive environment, no utility will able to afford to overcharge for electricity if customers will have the ability to shop elsewhere for cheaper power. Non-competitive utilities will not survive.

Second, environmental factors will also play a key role in technology choice. No electric generating technology is environmentally benign – all have an impact on the environment. Regulations such as the Clean Air Act Amendments of 1990 (CAAA), and numerous other wildlife and water quality regulations provide the framework within which electricity generation projects will be developed.

Finally, technological and operational constraints dictate the kind of generation options that fit specific needs. New coal plants are best suited to base load applications because of low fuel costs and economies of scale, while natural gas is well-suited to intermediate and peaking load because of its lower capital cost and ability to quickly be cycled in and out of the mix. Combustion-based renewable technologies can be used in base- and intermediate-load applications as long as they are connected to the grid and feed stock is available. Non-combustion renewables such as wind and solar cannot really be dispatched or counted upon, but do fit a number of so-called niche applications – especially where the demand is in remote areas not served by the grid.

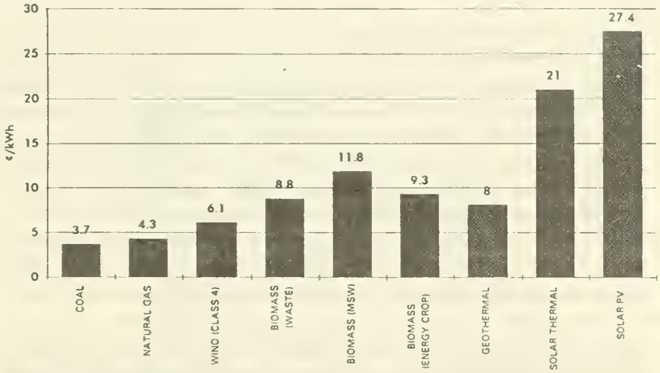
COST

No renewable electricity generating options are cost-competitive with new coal or natural gas plants. In spite of continuing gains made by renewables in chipping away at costs, the decline in the cost of traditional fossil technologies has outpaced that of renewables – fuels have become cheaper, generating efficiencies have increased and construction costs have plummeted.

Energy Choices compared the levelized costs of more than 120 technologies – that is, the capital cost amortized over the life of the plant, added to the operating, maintenance and fuel costs – and the following table summarizes the results for the most likely competitive technologies in each category:

Comparative Levelized Costs (¢/kWh)

1993 Data (Includes Existing Subsidies)



ENVIRONMENTAL CONSIDERATIONS

It is important to distinguish between two kinds of "renewable" energy alternatives for generating electricity: combustion and non-combustion technologies.

Contrary to popular perception, the lion's share of non-hydro renewables comes from combustion technologies which account for about 70% of all non-hydro "renewable" generation nationally, and about 90% outside of California. Combustion renewable technologies are generally referred to as "biomass," and they range from landfill gas (LFG) and municipal solid waste (MSW) incineration to the conventional burning primarily of wood and other agricultural waste products. LFG combusts methane gases that would otherwise have been flared or released into the atmosphere, however MSW generates highly toxic air emissions that would qualify as hazardous for other combustion technologies. Many jurisdictions have begun to shy away from this.

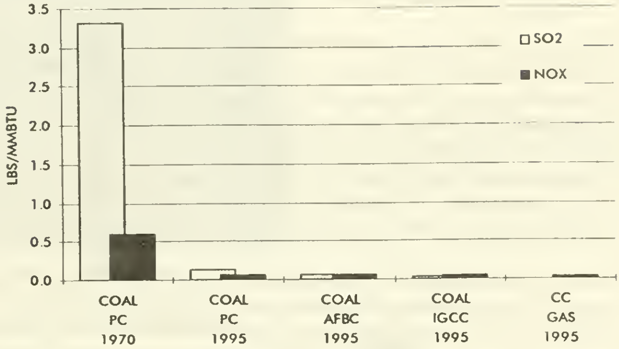
The combustion of agricultural waste presents the same emission problems as any other combustion – emissions must be controlled to meet local environmental requirements. The argument is often made that these wastes would otherwise be burnt in the open, so one might as well generate electricity with them. However, under PURPA, the high cost of burning waste products has been borne by utility ratepayers, not the agricultural industry creating the waste. Under deregulation, expect the electricity to bring only open-market prices, with the balance being borne by the "polluting" company.

A more recent, and highly controversial concept is that of cultivating energy crops, and even forests for the primary purpose of fueling boilers. Much greater environmental and economic concerns exist in the area of energy crop cultivation. Contrary to some claims, there is no net CO2 advantage to such practices, and significant environmental concerns stem from the land requirements for energy crop cultivation and the specter of harvesting forests for fuel. The National Audubon Society has stated that it would require 12% of the nation's farmland to generate less than 10% of its electricity. Ultimately, the lack of economic viability coupled with extreme environmental concerns and more valuable land-use alternatives will most likely dissuade any developers from pursuing this alternative.

Non-combustion renewable technologies (i.e., wind, solar and geothermal), while they exhibit little or no emissions, are not environmentally benign. Toxic chemicals are used in the development of Pv; geothermal can release hydrochloric acid and hazardous hydrogen sulfides; and wind must deal with tremendous barriers stemming from visual and noise pollution, plus the fact that it kills a significant number of birds – particularly raptors. One of the most promising wind power projects in southern Wyoming has ground to a halt because, among other things, of the criminal liability faced by developers in the likely event that eagles will be killed.

Coal and natural gas generation, following a long period of increasing regulation, must now comply with strict controls over emissions of particulates, SO2 and NOX. Typically thought of as "dirty" alternatives, the chart below indicates that new coal and gas technologies emit only a tiny fraction of the pre-1970, non-scrubbed coal technologies. CO2 remains the largest single question mark facing all carbon combustion technologies – biomass, coal, gas and oil. However, improving efficiencies and the ability to replace old technologies with newer state-of-the-art technologies will significantly reduce existing emissions, both nationally and world-wide.

Comparison of Emissions from Vintage and Modern Fossil Technologies



OUTLOOK

Curiously, RDI's outlook for the future of renewables under a base-case scenario is even more optimistic than that of advocates such as NREL. Essentially, given the attractive subsidies already in place following the Energy Policy Act of 1992 (~1.5 c/kWh) coupled with certain niche applications of Pv and some other non-economic applications such as MSW and LFG, we believe that renewables can grow from their current market share of 2% of all generation to 4% by the year by the year 2010. However, RDI has calculated that at today's differentials, the cost of this transition will be on the order of $50 billion when compared to the least-cost alternatives. If, over the coming decade and a half the cost gap between fossil and renewable technologies narrows, this number could decrease somewhat, but it will remain a significant factor.

Because of its relatively low capital costs, the currently low fuel cost, and the ability to add small increments of production, both turbine and combined cycle natural gas generating units will be the technology of choice for many utilities over the next ten years. We see gas generation doubling over the same time period.

Coal capacity utilization will continue to grow as base-load grows, plus several new coal plants are currently coming on line. Coal-fired generation will still garner the largest share of new electric generation.

RDI also postulated two alternative scenarios. One extreme assumes that as the U.S. moves to full and open competition, cost will be the driving factor in generation choice. For example, in California, biomass has gone from 880 MW in 1991 to 635 MW in 1994, and is projected to fall to 100 MW by 2000. In Maine, Central Maine Power recently bought out a 32 MW biomass plant that has never run for $76 million. Under a full and open competition scenario, renewables will actually lose market share falling to just 1% of the total generation mix, with the bulk of the gap being filled by natural gas.

The other extreme assumes that even more dramatic sufficient subsidies are imposed to make renewables cost competitive, and that development is constrained only by technology, geography and dispatchability. Under this scenario the maximum contribution of renewables would be only 11% of total generation. The price of this “subsidy intensification,” however would be more than $200 billion at today’s differentials.

CONCLUSIONS

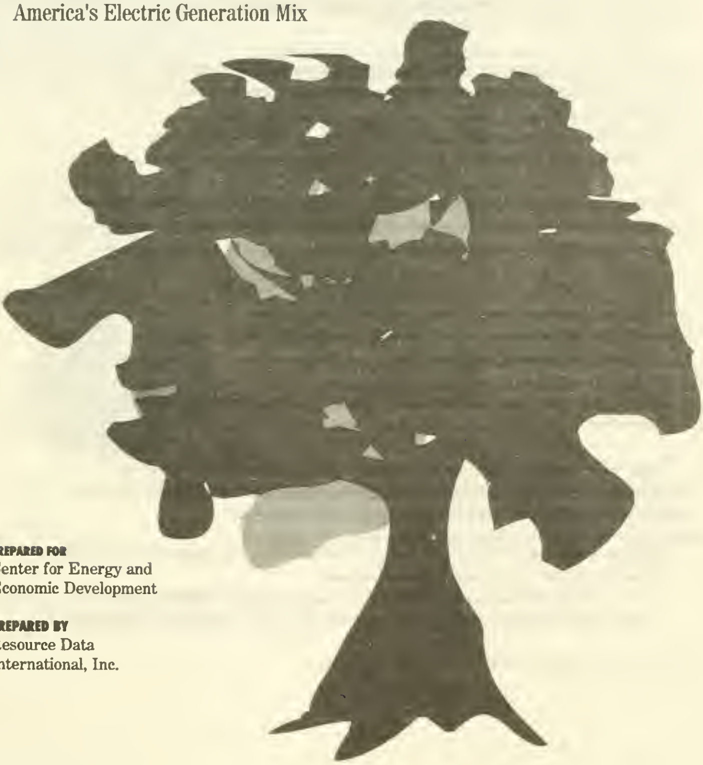
There is no debate today over the fact that renewable energy is much more costly than fossil for electricity generation. *Energy Choices* shows that under a business as usual scenario, incorporating current assumptions about existing subsidies and successes in commercialization, renewable’s market share could as much as double in the coming fifteen years to approximately 4% of the country’s generation mix. However, the cost, when compared to readily available fossil technologies will be significant.

If, however, the U.S. moves into an era of utility deregulation and intensified electricity competition, renewables generally will be unable to survive the market test, and will survive only in highly specialized niches.

Finally, trying to “force” renewables into the generation mix either through massive subsidies or through fossil penalties, will be economically devastating, and will not really accomplish a significant market penetration.

Energy Choices in a Competitive Era

The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix



PREPARED FOR
Center for Energy and
Economic Development

PREPARED BY
Resource Data
International, Inc.

Energy Choices in a Competitive Era

The Role of Renewable and Traditional Energy
Resources in America's Electric Generation Mix

April, 1995

SUMMARY OF KEY FINDINGS

Under current levels of tax incentives and regulatory support, renewable energy (excluding hydro technologies) is projected to grow from its current 2% of all U.S. electricity generation to 4% by 2010.

Such an increase in market share will occur at a cost of about $52 billion (in 1995 $) above today's most competitive power alternatives.

With open and direct competition in electricity, generation from renewable energy could shrink to just 1% of U.S. electricity in 2010.

Even with the imposition of exceptionally aggressive subsidies from public and private sectors, renewable energy would provide a maximum of just 11% of the nation's electricity by 2010.

Such an ambitious increase would cost taxpayers, consumers and/or utilities about $203 billion (in 1995 $) in subsidies between now and 2010.

All renewable resources have technological or logistical obstacles that limit their ability to produce and provide reliable electricity to the grid – obstacles that cannot be overcome, even through the use of subsidies.

Approximately 71% of non-hydro renewable generation currently comes from combustion technologies–not wind, solar or geothermal processes.

Outside California, nearly all existing renewable generation comes from combustion technologies.

All electric generation technologies, including renewables, present adverse environmental impacts.

Because renewables and natural gas occupy similar dispatch positions, gains in generation share by renewables will tend to displace growth in natural gas generation, and similarly, losses in renewables will tend to go to natural gas.

Despite government incentives and private sector subsidies, renewable resources cannot replace fossil fuels in the nation's generation mix.

Coal will remain the baseload fuel of choice, supplying more than half of all electricity generation in 2010, even assuming aggressive subsidies for renewables.

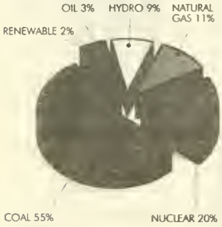
CENTER FOR ENERGY AND ECONOMIC DEVELOPMENT

Energy Choices in a Competitive Era

IN 1994, U.S. ELECTRIC UTILITIES GENERATED 3 trillion kilowatt hours of electricity from a mix of energy resources, including nuclear power, hydroelectric, coal, natural gas, oil, and emerging renewable technologies such as solar, geothermal, biomass, and wind. For the country as a whole, coal-fired power plants accounted for 55% of all utility and non-utility electricity generated, with nuclear power contributing 20%, natural gas 11%, hydroelectric 9%, and oil 3%. Non-hydro renewable energy sources, including biomass, municipal solid waste, landfill gas, solar, wind, and geothermal, accounted for 2%.

As the country moves forward, demand for electricity is projected to grow at a rate of 1.5% per year. New generating capacity must continually be added to the nation's fleet of power plants and choices must be made about which technologies to employ. At the same time, the electric utility industry is undergoing a profound period of change and uncertainty as the result of the Clean Air Act Amendments of 1990 (CAAA) and the Energy Policy Act of 1992 (EPAct). While the CAAA are affecting generation and fuel choices, EPAct is heralding in an unprecedented level of competition and affecting the very ability of some utilities to survive.

U.S. GENERATION MIX, 1994
(BASED ON UTILITY AND NON-UTILITY GENERATION)



SOURCE RDI 1995

This increasing emphasis on competition, in combination with the lowest fossil fuel prices in decades, is driving utilities and non-utility generation developers to choose traditional technologies for their capacity additions. For example, about 7,300 megawatts of new coal capacity are currently under construction or planned by utilities.

Meanwhile, the number of renewable energy plants under development has slowed dramatically and large portions of the renewable energy industry face economic failure as 1980s vintage power sales agreements based on high oil prices that were never realized begin to terminate, especially in California. Solar thermal, biomass, and geothermal will be the hardest hit, although some wind projects will also face difficulty. The national implications are apparent given that over 90% of the nation's solar, geothermal, and wind capacity is installed in California.

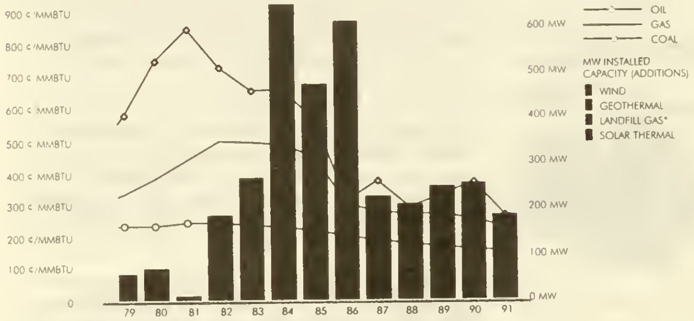
In response to the Public Utility Regulatory Act of 1978 (PURPA) and to the dramatic upsurge in oil and natural gas prices in the late 1970s and early 1980s, the renewables industry grew rapidly, with capacity additions peaking in the mid 1980s. However, as these new units were coming on line, oil and gas prices fell precipitously, resulting in a radical drop in renewable capacity additions by the early 1990s.

FUTURE GENERATION MIX SCENARIOS

Against this backdrop, public support for renewable resources persists for energy security and perceived environmental reasons. While the EPAct created barriers for further growth (and even re-licensing) of hydroelectric projects, it provides investment and production tax incentives for electricity generated from wind, geothermal, solar, and some types of biomass. This study examines the costs, capabilities, and feasibility of the various renewable energy technologies (excluding hydro), as well as state-of-the-art coal and natural gas technologies, and projects the future U.S. generation mix under three scenarios: (1) Base Case; (2) Full and Open Competition; and (3) Subsidy Intensification.

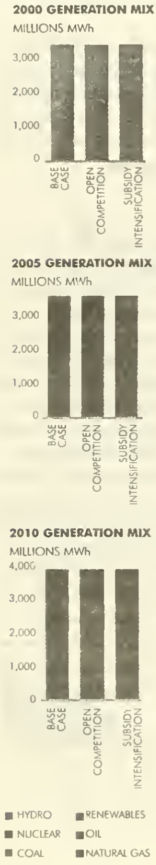
The results of this analysis show renewable technologies providing just under 3% of the U.S. generation mix by the year 2000 and about 4% by 2010, according to the Base Case

RENEWABLE CAPACITY ADDITIONS VS. DELIVERED FUEL PRICES
1979-1991



*BASED ON NUMBER OF PROJECTS PER YEAR AND MEAN CAPACITY OF 4 MEGAWATTS
DATA NOT AVAILABLE FOR BIOMASS AND MUNICIPAL SOLID WASTE
SOURCE RDI POWERDAT 1995, AWEA 1995, GAA 1992, GEOTHERMAL SOCIETY 1992, SAND91-7014

ELECTRIC GENERATION FORECAST UNDER THREE SCENARIOS



SOURCE RDI 1995

scenario. Coal continues to drive the electric generation sector as the foundation of the country's baseload capacity at 54% and 53%, respectively.

Because renewable energy projects are not cost competitive, a Full and Open Competition scenario predicts a dramatic reduction of non-waste derived renewable energy generation by the year 2000, resulting in economic failure under 1980s vintage contracts in California and the inability of proposed new plants to win power sales agreements or secure financing. Waste-derived renewables continue to operate and grow only as an alternative to the costs of landfilling, open burning, and other waste disposal options.

However, the most telling results occur under a Subsidy Intensification scenario which posits a 50% subsidization of renewables production costs -- bringing average levelized costs in line with today's most competitive power alternatives. Even with this level of subsidization, electric generation from renewables garners only a 4% share of generation by 2000 and 11% by 2010. At the end of the forecast period, coal maintains its key role as the baseload fuel of choice at 51% of the mix, although natural gas falls to 11%, down from 18% under the Base Case scenario.

Therein lies an important finding of this study–that renewable energy sources stand to gain at the expense of natural gas more than any other competing technology. The reasons are many, but include the following: 1) renewables and natural gas play similar roles in the dispatch order; 2) renewables and natural gas will compete directly for small to mid-sized generation additions; and 3) coal will garner over half of all new generation, first through increased capacity utilization at existing plants and then through the construction of additional baseload projects which provide reliability and economies of scale.

TECHNOLOGY REVIEW

Contrary to popular belief, electric generation technologies are not always interchangeable, since they exhibit important distinctions between capability, resource availability, locational feasibility, and cost. Even within the category of renewable energy technologies, important differences persist. Demarcations exist between technologies that are combustion and

COMBUSTION TECHNOLOGY OVERVIEW

LANDFILL GAS (LFG)

In addition to direct combustion, garbage can also serve as an alternative energy source in a gaseous form. Once a landfill becomes compacted and all aerobic bacteria (i.e., those requiring oxygen) disappear, anaerobic bacteria begin to proliferate. Over the course of anywhere from 10 to 100 years these bacteria produce quantities of methane and carbon dioxide (CO_2) gases, in addition to other trace elements, that must be vented and either flared-off or released into the atmosphere. Recognizing a potential resource, a number of landfills now recover these landfill gases (LFG) for electricity generation or resale into gas markets. In 1991, fully two-thirds of all recovery projects generated electricity from 377 megawatts of capacity.

BIOMASS

Installed U.S. generating capacity based on biomass fuels stood at 7,415 megawatts in 1992, with more than 81% of that figure consisting of non-utility generation from wood and lumber industry residues. In fact, biomass is the largest of all grid-connected renewable energy sources, representing almost half of all installed U.S. renewable capacity (not including traditional hydroelectric). In many senses, biomass is hardly exotic or even an "emerging" technology. Biomass boilers are not very different from coal boilers, and the idea of burning agricultural waste is not new.

What is radical, however, is the concept of cultivating energy crops, and even energy forests, for the primary purpose of fueling boilers. Although the Energy Policy Act of 1992 (EPAct) provides a 1.5¢ per kilowatt hour production tax credit to the technology, costs remain high and there are currently no plants in commercial operation. Siting difficulties and land requirements add to high costs in preventing development. One estimate holds that 12% of the country's farmland would be required to provide 10% of the nation's electricity from such power plants.

MUNICIPAL SOLID WASTE (MSW)

The Environmental Protection Agency (EPA) defines municipal solid waste (MSW) as residential and non-process industrial wastes, excluding industrial process wastes, hazardous wastes, municipal sludge, and construction or demolition waste. The United States generates over 200 million tons of MSW every year, with 84% of that volume consisting of organic material and 16% consisting of inorganic material, such as glass and metals. Residential waste accounts for between 55% and 65% of annual volume. Just less than two-thirds of all MSW is disposed of in landfills, with approximately 20% recycled and more than 17% incinerated.

While some parts of the public support MSW as an alternative to landfills, others decry the environmental impacts of incinerating garbage. Indeed, emissions of heavy metals and other toxic elements are much higher from the 2,300 megawatts of existing MSW plants than from any other combustion technology. Nevertheless, stricter EPA landfill regulations are increasing the cost of landfills with the effect of comparatively improving MSW economics.

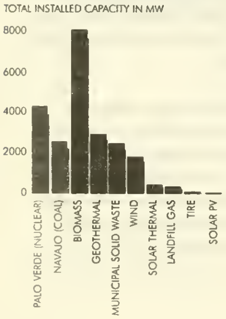
non-combustion, waste-derived and naturally occurring, intermittent and continuous, and land intensive and non-intensive. However, the renewable energy technologies considered in this study have all developed to the point of commercial application.

CAPABILITY

The essence of an electric generation technology may be summed up in a characterization of its capability. Capability in this study is defined as the ability to generate electricity based on generating capacity and availability. In other words, capability determines the extent to which a utility can rely on the technology to meet electricity demand.

At the most basic level, generating capacity determines the amount of electricity that a plant can generate at any one time. Renewables vary in this regard from micro wind, solar, and landfill gas sites of less than one megawatt to about 150 megawatts for the largest biomass, solar, and geothermal plants. New wind farms are also generally limited to 150 megawatts or less, although the largest farm in the world, Tehachapi in California, exceeds 600 megawatts. Limitations on size result from both technological optimization and limitation of the available energy resources. By comparison, U.S. coal plants average 706 megawatts and range to over 3,000 megawatts.

U.S. INSTALLED RENEWABLE ENERGY CAPACITY VS. CAPACITY OF ONE NUCLEAR & ONE COAL-FIRED PLANT



SOURCE RDI 1995

The ability of a utility to draw on generating capacity depends on the availability of the plant. Combustion technologies, such as coal, natural gas, biomass, municipal solid waste (MSW), and landfill gas (LFG), in addition to the non-combustion geothermal and nuclear technologies, present a high level of availability dependent only on planned and unplanned maintenance outages.

One indicator of availability is a plant's capacity utilization rate, which is a percentage of actual annual generation versus annual potential generation based on capacity. In this regard, new coal plants typically achieve capacity utilization in the range of 75-85% due to consistent fuel supply and relatively high availability, while LFG plants fare much worse as the result of unplanned outages that may average 51 weeks. Biomass agricultural waste plants may also experience somewhat lower capacity factors due to the seasonality of certain fuel stocks. Non-combustion technologies such as hydroelectric, solar, and

NON-COMBUSTION TECHNOLOGY OVERVIEW

WIND POWER

The United States is the world's largest producer of electricity generated from wind turbines, with installed capacity totaling 1,725 megawatts as of 1995. Although more than 90% of that capacity is located in California, utilities in six other states currently operate pilot projects. The further spread of wind power is limited geographically because the vast majority of the country's major wind systems are located in California and the Great Plains. Other limiting factors include the intermittent nature of wind, which results in a typical annual capacity utilization of 30%, and the land area required for siting wind farms. Avian mortality has also been cited as a problem, with preliminary studies finding hundreds of red tail hawks and dozens of golden eagles killed in turbine blades every year at just one wind farm in California.

SOLAR THERMAL

There are three well-developed solar-thermal technologies available today that can transfer solar energy into turbine-based electrical generation, including parabolic trough, parabolic dish and central receiver. All of these technologies rely on four system components: receiver, collector, converter, and transport/storage. Like wind, solar thermal technologies provide intermittent availability and are limited by resource availability to the Southwest and California. Although 354 megawatts of capacity are operating in California today, unfavorable energy market economics make development of new projects unlikely through the end of the century.

SOLAR PHOTOVOLTAIC

In 1994, over 400 utility sponsored Photovoltaic (Pv) sites produced close to 14 megawatts of capacity for the grid. While most of these utility projects are very small (less than 0.001 megawatts) and non-cost-effective in comparison to traditional generating technologies, industry specialists feel that Pv economics may some day be pushed over the threshold into market viability. This optimism is driven by the increasing production of consumer Pv cells (e.g., those used in watches and calculators) and a growing demand for stand-alone Pv systems in developing countries.

Nevertheless, costs currently remain high for central generation from Pv technologies. The most promising area for the technology lies in remote applications, where the cost of installing or upgrading distribution lines or substations may be more expensive than installing a Pv generator at a new demand center. In addition to economic limitations, solar Pv is limited by intermittent availability.

GEOTHERMAL

Four geothermal technologies are commercially available today: Dry Steam, Single Flash, Double Flash, and Binary Cycle. Dry Steam extracts naturally occurring steam from a well and runs it directly through a turbine. Flash plants pull hot water from a well into a separator tank where lower pressure allows a portion of the water to "flash" into steam and run through a turbine. Binary Cycle technologies run hydrothermal fluids in one loop and a power fluid (isobutane or ammonia) in another. These two loops align in a heat exchanger where the power fluid is vaporized and then run through a turbine.

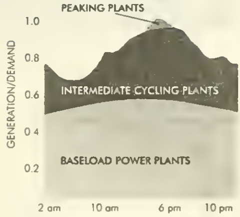
Geothermal plants have proven a high availability, reaching annual capacity utilization beyond 90%. However, as with the other naturally occurring renewable energy sources, geothermal is limited by resource availability. California, Nevada, Utah, and Oregon possess almost all economically recoverable U.S. geothermal reserves, although pockets exist in other western states. Of the 2,700 megawatts of U.S. operating capacity, 90% are located in California.

wind depend on natural forces to provide their energy and therefore experience lower levels of availability. Hydroelectric generation takes place primarily in the Spring when water is plentiful, while lower levels of generation occur in the Fall and Winter when water is more scarce. To some extent, utilities can control availability by storing water in reservoirs. Conversely, storage technologies for solar and wind generation are not yet commercially available. Utilities employ intermittent wind and solar generation according to seasonal and even daily statistical probabilities, but cannot predict availability with absolute certainty. Capacity utilization for these technologies falls below 30%.

DISPATCHABILITY

The ability to control and draw on capacity to meet different levels of demand is central to electric utility economics. Throughout the day, utilities experience a relatively constant level of demand called "baseload" and a moderately fluctuating level called "intermediate." Sharp spikes in demand are called "peaks" and can occur when a large number of customers demand power simultaneously. A typical demand peak, for example, occurs when everyone turns on their air conditioners on a hot summer afternoon.

A TYPICAL DISPATCH PROFILE



SOURCE RDI 1995

Utilities dispatch power plants at these different levels according to capability and cost. Plants assigned to baseload must be capable of continuously providing large amounts of electricity at a low operating cost, while plants assigned to intermediate load must be able to handle moderate fluctuations and are allowed a somewhat higher operating cost. Peaking plants must provide generation on very short notice, with less emphasis placed on cost. Therefore, coal and nuclear plants have historically served as baseload plants, not only because of their size, reliability, and low operating costs, but also because these technologies work best when operated at a continuously high level. Natural gas and oil serve as peaking units because of their higher variable costs and ability to increase generation quickly. Intermediate units consist primarily of larger gas plants with lower variable costs, as well as some older coal plants with moderate operating costs.

While renewable combustion technologies and geothermal may fit into this scheme, a special niche must be found for intermittent technologies. Solar and wind can neither be relied upon to provide large amounts of continuous generation for baseload nor can they be called upon to provide immediate generation for peaking. To adapt to these resources, utilities use intermediate or peaking generation to fill-in periods of low solar or wind generation. In a similar vein, some biomass plants provide generation seasonally, displacing traditional baseload or intermediate capacity when agricultural waste fuelstocks are plentiful.

Hydroelectric acts in the same way, with large displacements of coal and nuclear generation occurring in the Spring. Yet, this seasonal displacement of coal and nuclear plants is supported by the extremely low production costs of hydroelectric, while higher costs for solar, wind, and biomass generation provide little justification.

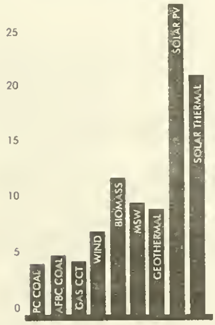
ECONOMICS

Production costs work in concert with capability to determine a plant's position in the dispatch order. If available, the least cost plants run first and the highest cost plants run last. This study compared the levelized production costs of the various renewable technologies, as well as coal and natural gas, to determine the competitive positioning of the technologies capable of providing new generating capacity.

There are three key factors that enter into the calculation of the levelized costs for each competing technology: 1) the cost of constructing and running the plant; 2) the projected cost of the fuel; and 3) the capacity utilization rate. RDI relied on EPRI's 1993 Technical Assessment Guide (TAG), in addition to vendor interviews, to determine the most likely plant designs and capital costs available today. For the cost of fossil fuels, RDI relied on its most recent regional fuel price forecasts as published in its *1995 Outlook for Coal and Competing Fuels.* Capacity utilization for fossil and combustion-based renewables plants is based upon the assumption that new plants will operate at the high end of the capacity currently attained by the newest state-of-the-art power plants for each technology. The following is a list of designs and operating parameters used in the base case cost analysis for each technology.

In order to compare the economics of various generating technologies, it is necessary to spread the capital cost over the plant's life and to add to this the projected ongoing operating and maintenance costs such as fuel and labor. In the chart below, the renewables subsidies provided by the EPAct have been factored into the levelized costs of these technologies, thus lowering their effective production costs.

LEVELIZED PRODUCTION COST COMPARISON, BASE CASE SCENARIO
(¢/KWH IN 1993 DOLLARS)



SOURCE RDI 1995

TRADITIONAL TECHNOLOGIES

- Pulverized coal (PC) plant with wet flue gas desulfurization located in the Southeast. One 400 megawatt unit burning bituminous coal, with an annual capacity utilization of 80%.

- Atmospheric fluidized bed combustion (AFBC) coal plant located anywhere in the U.S. One 200 megawatt unit burning bituminous coal, with an annual capacity utilization of 70%.

- Natural gas combined cycle turbine (CCT) unit located anywhere in the U.S. Capacity of 225 megawatts running at a 65% annual capacity utilization.

RENEWABLE TECHNOLOGIES

- Wind variable speed 0.2 megawatt turbine located in a Class 4 wind regime. Technology is based on the NREL Concept 1 with control electronics and advanced design airfoils placed on a 50 meter tower. Annual capacity utilization assumed at 29%.

- Biomass fluidized bed combustor burning wood and located in the West. One 50 megawatt unit operating at an annual capacity utilization of 70%.

- Waste-to-Energy (WTE) MSW mass burn plant located in the West. 40 megawatts operating at an annual capacity utilization of 70%.

- Geothermal Double Flash plant located in the West. 1 to 25 megawatt unit operating at an annual capacity utilization of 90%.

- Solar flat plate Pv located in the West. 50 megawatt capacity.

- Solar thermal parabolic trough located in the West. 80 megawatt capacity operating at a 40% capacity utilization.

Sensitivities were examined for financing assumptions, regionality and capacity factors. In the end, the analysis found that coal technologies are consistently the least-cost generating option. With delivered fuel prices declining by 40% to 50% in real terms between 1983 and 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas. At a levelized production cost of 3.3¢ to 4.4¢ per kilowatt hour under various discount rate assumptions, state-of-the-art coal PC boilers lead the list of new generating options, followed by AFBC coal plants at 3.9¢ to 5.2¢ per kilowatt hour. Natural gas CCT ranges in cost under these scenarios from 4.1¢ to 4.5¢. Renewables (including their subsidies) with the most promise include geothermal units with levelized costs ranging from 6.4¢ to 8.9¢ per kilowatt hour, wind at 5.2¢ to 8.7¢, and MSW from 6.9¢ to 11.9¢.

Cost estimates also varied regionally, with pulverized coal under the Base Case discount rate assumptions ranging from 4.2¢ per kilowatt hour in New England to 3.9¢ per kilowatt hour in the the South Atlantic. Natural gas combined cycle plants range from 5.0¢ in the South Atlantic region to 4.0¢ in the West South Central, and biomass from residue ranges from 9.3¢ in New England to 8.3¢ in the South Atlantic. In the end, a general analysis of the costs and capabilities of each energy resource may serve to educate, but a final decision about energy choices cannot be made without assessing the specific resources and projects in question.

With delivered fuel prices declining by 40% to 50% in real terms from 1983 to 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas.

In order to assess the costs associated with the anticipated growth in renewable electricity generation–that is, electricity generated for the grid–the study examined the implications of both the Base Case and the Subsidy Intensification scenarios:

The **Base Case scenario** projects that total non-hydro generation from renewables will grow from 75 billion kilowatt hours (BkWh) in 1995 to 180 BkWh in 2010. At today's differential between the levelized cost of the most competitive generation and the projected mix of renewables, the cumulative "above market" cost of this generation between 1995 and 2010 will be $52 billion (1995$).

The **Subsidy Intensification scenario** posits a 50% subsidization of renewable energy. Under this extremely aggressive scenario, renewables generation grows from 75 BkWh in 1995 to 450 BkWh in 2010. For comparison, this level of generation is roughly one-fourth of today's coal-fired generation, three-fourths of today's nuclear generation or 110% of today's gas generation. Using current levelized costs as a basis of comparison, to achieve this level of generation the cumulative subsidies would total $203 billion (1995$) between now and 2010.

LOCATION

Different regions of the United States are endowed with different energy resources. However, while coal, oil, and natural gas can be transported both physically and economically to other parts of the country, renewables generally cannot.

Different regions of the United States are endowed with different energy resources. The West enjoys ample solar radiation, wind, and geothermal resources, while the East enjoys abundant biomass resources. Natural gas and oil are concentrated in the Gulf of Mexico and Alaska, and coal reserves are situated in the Appalachians in the East, the Illinois Basin in the Midwest, and the various coal basins of the Mountain region and Southwest. However, while coal, oil, and natural gas can be transported both physically and economically to other parts of the country, renewables generally cannot.

The fact that 90% of the nation's current solar, wind, and geothermal generation resides in California is no surprise when looking at a map of where those resources are located. In fact, the potential for harnessing any of these resources outside of California and other parts of the West is limited or non-existent. While utilities in Vermont, New York, Minnesota, and Colorado may be planning wind demonstration projects, the capacity additions that they might realize will be relatively insignificant and pale beside the wind farms of California.

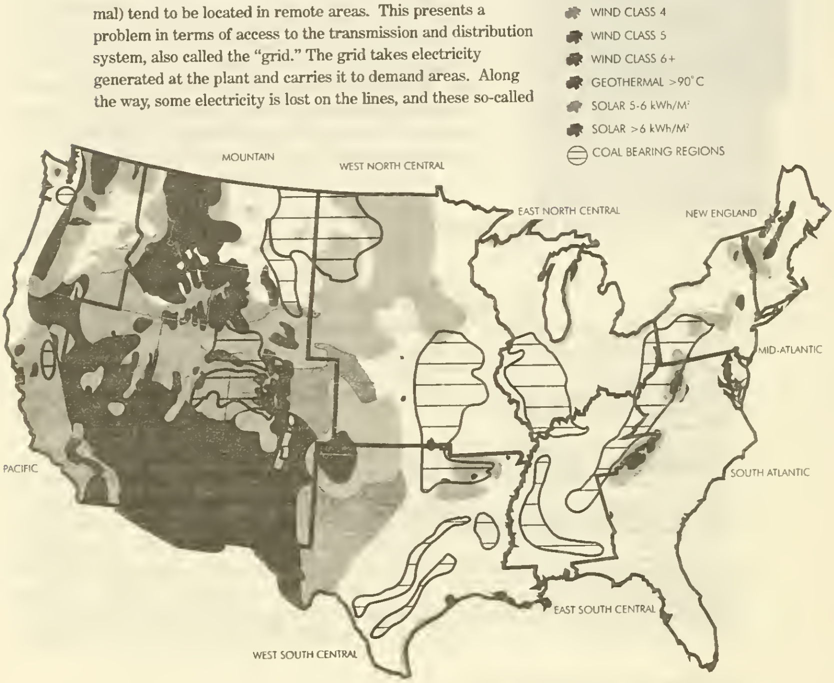
REGIONAL LEVELIZED COSTS, BASE CASE SCENARIO
¢/KWH

	SOUTH ATLANTIC	EAST NORTH CENTRAL	EAST SOUTH CENTRAL	MIDDLE ATLANTIC	MOUNTAIN	NEW ENGLAND	PACIFIC	WEST NORTH CENTRAL	WEST SOUTH CENTRAL	AVERAGE
Pulverized Bituminous Coal	3.9			4.1		4.2				4.1
Pulverized Subbituminous Coal		3.8	3.6		3.5		4.0	3.5	4.0	3.7
Atmospheric Fluidized-Bed Combustion–Circulating	4.6	4.5	4.3	5.0	4.2	5.1	4.7	4.2	4.7	4.6
Natural Gas Combustion Turbine/ Combined Cycle	5.0	4.3	4.4	4.3	4.0	4.5	4.1	4.0	4.0	4.3
Wind–Variable Speed Turbine–Wind Class 4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Wind–Variable Speed Turbine–Wind Class 5	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Wood-Fired Fluidized Bed Combustion–Residue	8.3	8.7	8.5	9.3	9.0	9.3	9.0	8.7	8.5	8.8
Wood-Fired Fluidized Bed Combustion–Energy Crop	11.5	11.8	11.7	12.5	12.2	12.5	12.2	11.8	11.7	11.8
Municipal Solid Waste–Mass Burning	8.5	9.3	9.0	10.6	10.0	10.6	10.0	9.3	9.0	9.3
Geothermal–Double Flash					9.2		9.2			9.2
Geothermal–Binary Cycle					8.0		8.0			8.0
Photovoltaic Central Station Flat Plate	28.7	31.6	32.8	42.4	19.6	38.4	24.5	24.1	23.5	27.4
Solar Thermal–Parabolic Trough					22.59		21.87		20.22	21.0

Similarly, low levels of rainfall in the West prevent agricultural and lumber industries from reaching the scale of such industries in the Southeast, Midwest, Upper Midwest, and Pacific Coast, and the low heat content of biomass fuelstocks generally prevents their economic transport beyond 50 miles. As a result, biomass generating technologies are limited in the West. The same follows for MSW and LFG generating technologies, which must be located near a metropolitan area or landfill. By comparison, coal is distributed to 47 of the 50 states for conversion into electricity.

A more specific locational issue relating to renewable energy is the fact that non-waste resources (i.e., solar, wind, and geothermal) tend to be located in remote areas. This presents a problem in terms of access to the transmission and distribution system, also called the "grid." The grid takes electricity generated at the plant and carries it to demand areas. Along the way, some electricity is lost on the lines, and these so-called

U.S. NON-COMBUSTION RENEWABLE ENERGY RESOURCES AND COAL RESERVES



RESOURCE DATA INTERNATIONAL INC • **EXECUTIVE SUMMARY 13**

In 1995, state-of-the-art pulverized coal (PC) and fluidized bed combustion (AFBC) coal technologies present only 1-3% of emissions of earlier designs and compare favorably to integrated gasification and natural gas combined cycle turbines. All coal plants meet or exceed federal and state environmental regulations.

"line losses" increase with distance and the load on the grid. This fact, plus the considerable expense of building new transmission lines ($600,000 to $1 million per mile), severely impedes the construction of any power plant at a remote site unless it enjoys adequate economies of scale. Most renewable energy power plant projects do not exhibit such economies.

Finally, the large areas required by some renewable technologies also serve to further limit location. To supply just 10% of the nation's electricity demand with biomass generation, the U.S. would be required to plant more than 12% of all farmland with energy crops, such as hybrid poplars. For wind, one estimate calculates that 25 square miles would be required for a 50 megawatt farm. Likewise, solar thermal projects require roughly one-third square mile for each megawatt of produced electricity. Geothermal plants, however, require very little land, but are often located in wilderness areas.

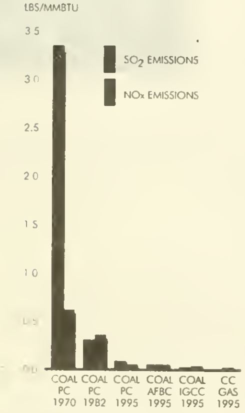
ENVIRONMENTAL IMPACTS

The Public Utility Regulatory Policy Act (PURPA) of 1978 is largely credited with creating the current U.S. renewable energy industry. However, PURPA originally intended to diversify the national generation mix for reasons of energy security, while renewable technologies are being pursued today because of their perceived environmental benefits.

Wind, solar, and geothermal present little, if any, emissions, and biomass, MSW, and LFG provide an alternative to landfills and open air burning of waste. Nevertheless, all energy technologies present environmental impacts. Wind, for example, consumes no fuel or water and gives off no emissions. However, it does present visual and noise pollution and kills a significant number of birds, particularly raptors, that fly into turbine blades. Solar Pv also consumes no fuel or water, but the Pv manufacturing process can involve hazardous chemicals that must be disposed of. Likewise, geothermal binary system plants create no emissions, although flash designs release hydrochloric acid and potentially hazardous hydrogen sulfides.

Combustion technologies cover a range of environmental impacts depending on the fuel combusted. The combustion of agricultural waste tends to be relatively benign, given that agricultural prunings and lumber residues would otherwise be

COMPARISON OF EMISSIONS FROM VINTAGE COAL & GAS TECHNOLOGIES



SOURCE PACE, STANLEY AND DALE SOPOCY, "DEVELOPMENT OF AN ECONOMICAL ADVANCED PULVERIZED COAL UTILITY PLANT COMMERCIAL DESIGN" burned in an uncontrolled environment, and the same may be said of LFG which combusts methane gases that would otherwise have been flared or released into the atmosphere. MSW, on the other hand, generates toxic air emissions that would qualify as hazardous for other combustion technologies. Coal-fired power plants, which also employ combustion technologies, comply with a myriad of environmental regulations covering water, land, and air use. The most conspicuous of these is the Clean Air Act of 1970 and its amendments in 1977 and 1990. That legislation requires all new coal plants to employ smokestack technology that currently removes up to 95% or more of all sulfur dioxide (SO_2) emissions and provides limits on the emissions of SO_2 and nitrogen oxide (NO_X) from all existing plants. Largely as the result of these laws, SO_2 emissions in 1993 were lower than those in 1971, despite a doubling of coal-fired electricity generation over that period. When the CAAA take full effect in the year 2000, SO_2 emissions will be reduced by 62% and NO_X emissions by 33% from the levels generated by utilities in 1980.

Renewable energy advocates are increasingly heading to public policy forums as they fail to make their case in the open market. Southern California Edison calculated a cost of $560 million that would result from the state's latest round of renewable energy mandates (which were subsequently ruled out by the FERC).

PUBLIC POLICY SUPPORT

Acknowledging capability, dispatchability, economic, and location limitations, state and federal legislatures and regulatory bodies continue to support renewable energy technologies, partly as a measure of prudence in developing the energy resources of their region, but mostly because of their environmental appeal. Proponents cite the public benefits from the development of wind, solar, and geothermal resources, as well as the controlled combustion of agricultural and lumber waste in place of open burn.

However, such support comes at a cost. The California Biomass Energy Alliance, anticipating certain economic failure of its industry in an era of increasing competition, has proposed a 25¢ per month surcharge on ratepayers that the California Public Utilities Commission may consider in order to subsidize biomass plants. Southern California Edison calculated a cost of $560 million that would result from the state's latest round of renewable energy mandates (which were subsequently ruled out by the Federal Energy Regulatory Commission). In addition, EPAct provides a 1.5¢ per kilowatt tax credit to wind and certain biomass technologies, as well as a 10% investment tax credit.

States adopting externalities are also imposing a cost on the public by increasing the local cost of electricity. Under the deregulation provisions of EPAct, industrial and large commercial electricity customers will be able to shop outside the state for cheaper electricity, while residential ratepayers will not. In short, advocates for renewable energy technologies are increasingly heading to public policy forums as they fail to make their case in the open market.

> In the final analysis, current renewable energy technologies tend to fill niche power market opportunities made possible by subsidies, high waste disposal costs, and, to a lesser extent, unusually strong renewable energy resources at specific sites.

CONCLUSION

On the whole, renewable energy technologies have demonstrated a limited commercial ability to produce electricity, some with environmental impacts that balance positively against waste disposal alternatives. Certain technologies in certain situations can hold their own in today's competitive marketplace. In most cases, however, the lower costs of traditional generating technologies have outpaced the gains made by renewables, and some sectors of the renewables industry face contraction rather than expansion.

This study demonstrates the capabilities and limitations of renewable energy technologies and provides a measure of reasonable expectation for their continued application. All represent niche technologies that can work in specific situations, while none offer a means to replace traditional generating technologies under current market conditions. Solar and wind do not have the capability to replace baseload coal plants, and biomass does not have the capacity. Few renewable technologies are economically competitive.

Meanwhile, reductions in hydroelectric capacity, due to new reservoir management regulations, and nuclear capacity, because of plant retirements, leave coal as the primary baseload energy resource capable of meeting the nation's growing energy demand. In that regard, continued favorable economics and dramatically improving environmental controls promise to reinforce coal as the fuel of choice, especially for baseload generation, well into the twenty-first century.

For More Information or the Complete Study...

Contact CEED with any questions regarding this study or to receive a copy of the full study. Copies of RDI's levelized cost model in an Excel™ 5.0 format are also available from CEED at a cost of $50.00 per disk. CEED is a non-profit organization.

The Center for Energy and Economic Development
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facsimile: (703) 684-6297

Resource Data International, Inc. (RDI) has gathered the information in this study and in the levelized cost model in Excel™ 5.0 on behalf of the Center for Energy and Economic Development (CEED) from interviews, documents, and data tapes available from the United States and state governments, industry organizations and contacts, federal laboratories, newspapers and magazines, and from published material provided by government and private agencies and organizations. This information has been cross-checked and verified wherever possible and is intended to be accurate. RDI and CEED, however, cannot insure against or be held liable for inaccuracies, and neither RDI nor CEED shall be liable for any loss or injuries whatsoever from contingencies beyond their control or from negligence.

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Chairman ROHRABACHER. I think that $200 billion is a tidy sum.

Dr. MCMAHAN. Oh, okay.

Chairman ROHRABACHER. Well, thank you all very much for your testimony. And, we will proceed now with questions.

Did you have something else to say, Ms. Ervin?

Ms. ERVIN. No, sir.

Chairman ROHRABACHER. Okay. Ms. Ervin, your office has shown a steady decline in the number of full time employees over the last two years.

However, the number of political appointees has nearly doubled in that time. Could you give us a little understanding of what that's all about?

Ms. ERVIN. I don't have the number of political appointee figures with me over time. But, I will tell you that the Department does have an allocation of political appointees and it is then the Department's responsibility to allocate them within——

Chairman ROHRABACHER. Right. Well, this is one of those pesky little questions that we would like to get answered.

And, so if you would like to further explain that——

Ms. ERVIN. I would be happy to submit that to the record.

[The following information was received for the record:]

The appointment of non-career employees during FY 1994 reflected the President's 1993 Climate Change Action Plan and the Vice President's National Performance Review which increased the Office of Energy Efficiency and Renewable Energy's (EE/RE) program priorities in the areas of energy partnerships and customer service. Thus, the number of political appointees increased from 11 to 15 from FY 1994 to FY 1995. However, that initial increase was followed by a 7% decrease in political appointees from FY 1995 to the present (currently 14 political appointees). During that same time period career employment declined 13%.

Chairman ROHRABACHER. For the record, I think that might have been one of the questions that we submitted to you that you heard about earlier. It might not have been.

Your budget request calls for a substantial reduction in the number of employees for 1997. Now, will these employees that you are planning to reduce, is that coming from career employees or will you also be including a number of political appointees as well?

What's the plan?

Ms. ERVIN. We are going to have an equitable downsizing of the Department. And, I would be happy to share more details with you on the process that we are using.

It's a very elaborate personnel and labor-driven process to determine that we reach our streamline—the figures—appropriately. I would be happy to share that with the Committee.

Chairman ROHRABACHER. When you say "equitable," does that mean that your—are you testifying today that you expect the number of political appointees that will be released as well as the career appointees to be about equal to their number in the Department?

Ms. ERVIN. I would expect that to be the case. But, I would be happy to follow up with you on that.

[The following information was received for the record:]

EE/RE has targeted FY 1997 reductions in the number of career employees. Our target is to reduce the total number of employees from 579 in FY 1996 to 538 in FY 1997. The Department allocates and manages the usage of political appointments agency-wide. Likewise, the Department will oversee any reductions in these allocations.

Chairman ROHRABACHER. All right. All right. I will be very happy——

Ms. ERVIN. You bet.

Chairman ROHRABACHER. (continuing) to take a look and see where they are coming from when we get a list of the people being let go.

Under the Energy Research and Development budget, what we see here is that there have been 100,000 brochures distributed. And, there have been town hall-sponsored and media events that have been sponsored.

Could you explain to me what does—how does this—you know, first of all, how much does that cost? What is the cost of that particular element of your "Research and Development" cost?

Ms. ERVIN. And, what program—may I ask what program are you looking at?

Chairman ROHRABACHER. It's in your testimony today.

Ms. ERVIN. Okay. Let me address the issue more broadly, though.

We are directed under EPACT and a number of other provisions to provide information to the public on our programs. We take that mission very seriously.

Not only that, when we are dealing with the various kinds of market imperfections, if you will, you need to overcome barriers to the exceptions of these technologies by getting effective information out. And, so one of——

Chairman ROHRABACHER. Yeah. But, you don't know how much that costs?

Ms. ERVIN. (continuing) the things that I've been—pardon?

Chairman ROHRABACHER. You don't have an idea about how much you are paying for this?

Ms. ERVIN. No, I really don't. But, again we can provide an estimate for you.

[The following information was received for the record:]

Brochures and other documents provided public information on alternative fuels and vehicles as provided in the Energy Policy Act, Section 405. These documents are developed in partnership with our industry stakeholders to provide objective information to fleets, consumers, local government planners, auto companies, and more. To date, we have printed approximately 140,000 brochures at an approximate cost of $88,000, for an average cost per document of about 60 cents. We are now putting many of these documents on the electronic World Wide Web, which will improve access and reduce printing costs even further.

Chairman ROHRABACHER. Okay.

Ms. ERVIN. I will tell you, though, that it has been one of my priorities over the last year to actually improve the effectiveness of the way that we distribute information and to make reductions in the amount of money that we spend on information materials. I can also provide examples of how we have streamlined our information programs to do just that.

Chairman ROHRABACHER. Well, what this does is come to the central issue that—and Mr. Nemtzow mentioned it in his testimony, which is we are talking about commercialization actually of technologies. And, let me say that again and again and again this issue emerges from this particular Committee.

And, what it is is that where our priorities should be. Now, let me state that when you have an expanding budget that we had for so many years with no hope of ever finding a balanced budget, well then it's easier to get by without setting any priorities. I mean, then there is no need to set priorities, because everybody is in an expanding budget.

Well, once the decision is made that you have to set priorities because you are going to reach a balanced budget, that means you've got to say, "Well, what is our core mission here? What is more important than other things?"

And, while I agree with Mr. Nemtzow and I agree with most of the people I've heard from the Department of Energy about the desirability of certain programs that will help bring about these projects, these R&D projects, that we develop like that beautiful window there, you know, it may be something that if we had all the money in the world we might say, "Hey, we are going to be involved in commercialization and that's going to be a major part of our budget."

Unfortunately or fortunately, depending on your outlook, when we had to make a decision as to what the priorities would be, at least from the Republican standpoint—and I can't speak for the Minority here—we decided that research and development was going to be the priority, especially for the money going through this Subcommittee and that energy and environmental research and development was going to be where the money would be spent and we would cut money from other areas that were not in order to maintain the research and development.

Now, commercialization and what you are talking about in terms of the brochures and the sponsored town hall meetings and the different things to get the word out, as well as what Mr. Nemtzow is talking about in terms of commercializing that window, that doesn't fall under that category. And, what I would like is just your reaction to that.

And, then I will move on to Mr. Roemer and he can have his time to ask some questions. Is this not what our priority should be?

If you have to spend a limited amount of money, shouldn't it be on research and development and let the profit-making companies commercialize the products of that R&D?

First, go ahead, Mr. Nemtzow. And, then we will let you finish up, Ms. Ervin.

Mr. NEMTZOW. You are absolutely right, in that in a time of tight fiscal constraints such as the current, priorities have to be made. I think the prioritization process is quite simple.

What are the national priorities? Environmental protection, job creation, saving consumers money so they can spend it on something other than energy.

That should guide the prioritization. So, the energy choices that you recommend, Mr. Chairman, should reflect those priorities.

And, energy sources that can perform to contribute to those priorities should be supported. And, energy sources that cannot perform should not be supported.

It's really that simple. And, that's why energy efficiency and renewable energy score at the top of the list.

If you want to make a distinction between basic research and applied and commercialization——

Chairman ROHRABACHER. Will you concede to me that there are people who are expert and have PhD's—and they can bring them in from both sides—that no matter what energy source you are talking about that you are going to have someone arguing, "Now, this is the one we should push beyond R&D," and people who are actually smarter than either one of us can sit down and make their case?

So, wouldn't it be better just to make sure that we put the money into basic R&D and let the other part handle itself rather than what you are advocating now, which is making the choice ourselves as to what actually is going to be the best benefit for the country as a whole?

Mr. NEMTZOW. You are absolutely right, in that people will make the case for different energy sources. But, we have a track record.

And, the fact is the United States consumes 20 percent more energy than we did in 1973 before the oil crisis—20 percent more energy. Our GDP is 70 percent greater.

We are much more energy efficient than we were. It's successful.

It's meeting all the standards you need. So, we have a track record.

There may be scientists or consultants who argue for different sources. But, I don't think this is a tough call.

I would also like to point out in my testimony—it's on Page 7—I talk about the standards that you should use in deciding among the different research priorities. And, the most important standard is what I said earlier. Does it contribute to key national priorities?

But, after that, the question should be. Will the private sector do it on its own? And, if they will, I agree with you, you shouldn't spend your limited money on it. If they won't, you should contribute.

I peeled the label off the window. It's not a brochure, but it is a label. There is no science here. The clever science is in that film.

But, the problem is that a lot of the companies who make this made claims that they couldn't support. They were really exaggerated claims about the performance of the window.

So, the Department of Energy and the window manufacturers, the Alliance and many other groups set up something called the National Administration Rating Council. All it is is a uniform standard for measuring the performance of those windows.

This one is a .32. That's pretty good. There's better ones out there. There's .19s.

But, the point is that it's a consistent standard so that when the consumer, who is not a scientist, goes in, they will know what they are getting. That's the important point.

In Mr. Wamp's district, they have a lot of scientists at Oak Ridge, at Lawrence Berkeley Lab. Those technologies won't be useful if consumers can't get their hands on it.

So, I think it's better to do a few things well rather than to draw an arbitrary line.

Chairman ROHRABACHER. Thank you for those comments. Ms. Ervin, do you have a short rebuttal or insight into——

Ms. ERVIN. I don't think there is any rebuttal here to anything that Mr. Nemtzow just said. I would——

Chairman ROHRABACHER. I was talking more about in terms of my comments on R&D versus commercialization.

Ms. ERVIN. Pardon?

Chairman ROHRABACHER. I was talking more in terms of my comments on R&D versus commercialization.

Ms. ERVIN. Yes. Well, you know, you are right. We have talked about those distinctions quite a bit.

And, I think we could talk about the differences in terms, but I think to really have a meaningful discussion you should break down the artificial walls between the stages of development. You need a balanced portfolio in order to get the results from the technologies that we win.

We have an outstanding success record, as Mr. Nemtzow has suggested. If you look at the R&D, 100 awards, for example.

These technologies are winning a greatly disproportionate share of the successes. And, we have large dollars savings to speak to that.

In fact, I would like to come back to the GAO report in some detail on just that matter. Let me give you an example of——

Chairman ROHRABACHER. I will tell you what. Why don't we move on to Mr. Roemer——

Ms. ERVIN. Okay.

Chairman ROHRABACHER. Because otherwise I don't think anyone else would get a chance to ask any questions.

Ms. ERVIN. Fine.

Chairman ROHRABACHER. Mr. Roemer, go right ahead.

Mr. ROEMER. Thank you. Mr. Chairman, I would just ask unanimous consent to have a statement entered by Ms. Sheila Jackson-Lee for the record.

Chairman ROHRABACHER. Yes, without objection.

Mr. ROEMER. Thank you, Mr. Chairman. Mr. Li, I want to start with you, since my opening statement started with some criticism of the General Accounting Office.

And, let me qualify this criticism by saying that I have the deepest respect for the General Accounting Office and oftentimes go back to my district taking religiously what you've said in your studies to my constituents. And, I've got to tell you, quite frankly, with this report that you folks have done that I'm not sure that I can do that anymore.

Now, just quickly, you have been with GAO how long?

Mr. LI. Sixteen years, sir.

Mr. ROEMER. Sixteen years? And, you have been overseeing this particular area, this particular study, for its whole seven month——

Mr. LI. No, sir. I've been in the Issue Area for two months.

Mr. ROEMER. Two months? This is a seven month study, and you've been overseeing this for two months?

Mr. LI. Yes, sir.

Mr. ROEMER. So, to follow up on your analogy of football with Mr. Largent, this issue has been handed off to you?

Mr. LI. Yes, sir.

Mr. ROEMER. Okay. Let me say, reading from the GAO report, somebody writes. "In addition, 'Success Stories' does not..."

Chairman ROHRABACHER. Mr. Roemer——

Mr. ROEMER. Yes, Mr. Chairman.

Chairman ROHRABACHER. Could I interrupt just for a matter of personal privilege for one moment?

Mr. ROEMER. I would be happy to.

Chairman ROHRABACHER. Mr. Schiff, do you have a motion for a personal privilege request?

Mr. SCHIFF. Actually, it wasn't—I didn't mean to interrupt. I only indicated that when I could be recognized, I was going to ask for a question to be answered in writing. That's all.

I did not mean to interrupt the——

Chairman ROHRABACHER. Why don't you go ahead and ask that question?

Mr. SCHIFF. As long as I have interrupted——

Mr. ROEMER. Mr. Chairman——

Chairman ROHRABACHER. We know that Mr. Schiff has a special—he's a Chairman of another Subcommittee, and he has to move on. And, if we could just give him that courtesy to ask that one question to be in writing——

Mr. SCHIFF. Well, I apologize.

Chairman ROHRABACHER. Go right ahead. Go right ahead, Mr. Schiff.

Mr. SCHIFF. Okay. I didn't mean to interrupt anybody. All I wanted to ask is, Secretary Ervin, I have a few questions that have come to my attention related to energy use in New Mexico and I don't want to hold the whole Subcommittee on that subject.

And, I wonder if I submit written questions through the Subcommittee staff, would you be kind enough to answer them in writing later?

Ms. ERVIN. I would be happy to. We have some good work going on in New Mexico.

Mr. SCHIFF. All right. I thank the gentleman for yielding.

Chairman ROHRABACHER. Okay. And, I apologize to the Ranking Member.

And, we are going to start his time over again. And, I apologize for interrupting.

Mr. ROEMER. Thank you, Mr. Chairman. In your GAO report, Mr. Li, you say, "In addition, 'Success Stories' does not report how much DOE has spent to support any of the technologies we evaluated."

Now, I have "Success Stories" right here. And, it says on Page 4, the fourth paragraph, "The electronic ballast has not only improved lighting quality but has saved consumers $750 million in consumer energy bills from a $3 million research and development investment."

Now, how do you explain that?

Mr. LI. Yes. I recognize what you are saying, sir. The point that we were making was the overall investment.

Both of the references that are in the "Success Stories," one on the windows and one on the fluorescent, the one I believe on the windows was talking about investment through the 80s. And, our point was to take a look at the entire investment of each individual one and totalling so we could have some sort of balance between what we spent and what we got out of it.

Mr. ROEMER. Isn't all of this available in a public document the GAO would have access to and that you would just, in checking your facts and peer review, be able to correct something like that?

Mr. LI. I'm glad you asked that question, sir. In our methodology, the methodology that we utilized—and, you know, you made reference to the fact that I've only been here for two months in this particular assignment, but I want to make sure that you understand that the processes that we use in all of our areas is the same, in that we try to get—and the purpose of this particular review was to establish whether or not DOE had the supporting documentation behind its numbers and the claims.

And, I appreciate the cooperation that the Department gave to us. But, we had some difficulty in getting that information.

Mr. ROEMER. Mr. Li, but——

Mr. LI. Yes, sir.

Mr. ROEMER. What I am upset about, quite frankly, is that, you know, this is not even the analogy of making a mountain out of a mole hill. This is where you have almost agreed that there is $10 billion in savings from a host of very successful programs, including the window that we just saw, and then the first few sentences and paragraphs of the GAO study almost says, "Because we have problems with a few things in the methodology or some typographical mathematical errors, we are going to try to dismiss $10 billion worth of savings."

Mr. LI. Sir, I don't believe we say that. And, that was not the intent.

What——

[The following information was received for the record:]

[What] ... our report said was that "although *Success Stories* makes some valid claims about the benefits of DOE's applied research, we found problems with the analysis DOE used to support the benefits cited in eleven out of the fifteen cases we reviewed. These problems make DOE's estimates of the benefits for these cases questionable."

Mr. ROEMER. But, you agree that the Department of Energy, through "Success Stories," has saved the taxpayer approximately $10 billion just in these three programs of the software for building design——

Mr. LI. Yes, sir.

Mr. ROEMER. (continuing) the windows——

Mr. LI. Yes, sir.

Mr. ROEMER. (continuing) and the refrigerator compressor?

Mr. LI. Yes. The point I would like to make, sir, is that while there are savings, our main point—and I think that this is what perhaps the discussion should be moving towards and this is what I'm suggesting, that while there are individual methodological differences between the Department and ourselves, I think the bigger issue is our second point.

And, that second point is the following. Can we use documents such as "Success Stories" to establish whether or not our investment in research and development is good?

And, I think that's what I'm getting to. I think the individual look at individual success stories is not the answer.

And, I was trying to be able to, at least, establish whether or not the claims that were being made had the documentation. But, it's really that second point.

And, I would like to try to get back to that point, in that I believe—and I know there are some differences in DOE and ourselves, in that I believe that we need to know the costs associated with our investment. In reading the documentation and in reading even the press release that the Secretary recently made regarding the budget, she talks about making a prudent investment, that the taxpayers want prudent investment, that DOE is the steward for the taxpayers.

And, that's all I'm saying.

Mr. ROEMER. Well, let me just stop you there and then give Secretary Ervin and Mr. Nemtzow the opportunity to answer, I think, that question.

Are we, in $10 billion in savings, getting some of our money's worth?

Ms. ERVIN. Well, I would like to take strong exception to the comment that you just made. I think this is a very valid and, in fact, an exceptional tool to use for validating the investment that we have in these R&D portfolios.

In fact, I would like to show a chart over here on this wall. You have just said, Mr. Li, that a number of the estimate figures are not disputed.

And, we've already gone into some detail about the basis for those. So, if you look at the top two, for example, for which there is no dispute on the methodology or the estimates, you find a total savings of $7.9 billion.

That already exceeds, on the bottom line, the total cumulative amount of budget that has gone into these programs since 1976. That's not bad for just two technologies.

Add three more that were fundamentally not disputed. We made adjustments based on your suggestions.

A number of them were good ones. You did not qualify it in any further way.

You add them up. That's $11 billion to the $7 billion cumulative investment.

So, to the contrary, I think it's an excellent tool to use. If you take the analogy of looking at stocks and dealing with high risk research projects, you expect many, many more to fail than to succeed.

We've picked a handful of hundreds of technologies. And, these are the kinds of outstanding results you get.

Mr. ROEMER. Mr. Nemtzow, would you just refresh the Committee's memories as to what your organization is all about and who comprises your organization and your feelings about "Success Stories" as well?

Mr. NEMTZOW. Yes, thank you.

Mr. ROEMER. Many members were not here when you made your opening statement.

Mr. NEMTZOW. Sure. The Alliance to Save Energy is a coalition of government, business, consumer and environmental leaders and includes several members of the Senate and House and state officials, as well as 85 companies, companies from all walks of life—

utility companies, manufacturers, big companies like AT&T that use a lot of energy in doing business and——

Mr. ROEMER. You had better start using another example for the——

[Laughter.]

Mr. NEMTZOW. Boeing.

Mr. ROEMER. There you go.

Mr. NEMTZOW. And, the important point here is that they believe, and we believe, strongly in public/private partnership. And, that's why, I think, one of the key areas—just reading the GAO report for the first time now is it's bigger than methodology.

GAO makes the point, I believe—and I will let Mr. Li speak to that—that DOE shouldn't claim too much credit for their work, that there are a lot of other players involved. And, that's correct.

You don't want the Department of Energy to be doing anything singlehandedly. That would be crazy. They should be doing it in partnership with others.

So, these numbers are very powerful. Your investment that Congress has made in this Department has paid itself back already several fold.

But, more importantly is if you want to be able to say what happened just because DOE did it or any other agency, it won't work. You won't come up with a good answer.

What you have to ask is what technologies, what science is there that would not be there if DOE wasn't around? That's the key question.

And, working with the private sector is how they do their job, as I think we expect them to.

Mr. ROEMER. And, in conclusion, Mr. Chairman, I thank you for your extra time here that you've given me. And, I would say very, very proudly that the United States Congress and the Department of Energy are not trying to take credit for success stories.

It is because of organizations like the Alliance to Save Energy and the companies that comprise that membership that we come up with these programs in partnership, in cooperation and in bipartisan ways and not that we are claiming government credit for these kinds of things. And, I thank you.

Chairman ROHRABACHER. Well, I apologize for interrupting your train of thought during your questioning. I was actually just trying to be courteous to one of our members but made a bad judgment call in that.

Mr. ROEMER. I appreciate that.

Chairman ROHRABACHER. And, Ms. Rivers.

Ms. RIVERS. Thank you, Mr. Chairman. I have a quick question for Ms. Ervin and then I have some questions for Mr. Li.

Ms. Ervin, earlier when I asked my questions about the prehearing requests that were put in on this, there was a suggestion that one of the reasons these questions, 569 of them, were required is because there was something different this year about the way the budget was presented.

Is there—what things were different about how the budget was given this year as opposed to last year or the year before?

Ms. ERVIN. We made a number of changes to our budget request but many of them improvements. And, they should be more responsive to information needs.

For example, in the energy and water appropriations, we worked closely with staff to provide information in a way that we mutually thought would be beneficial. And, we are doing the same thing on the Interior side.

Ms. RIVERS. So, it has improved, if anything?

Ms. ERVIN. I believe it's improved. We certainly——

Ms. RIVERS. Okay. Thank you.

Ms. ERVIN. (continuing) want to be responsive.

Ms. RIVERS. Thank you. Mr. Li, I have several questions for you. And, I was going to ask some general questions, but I think I am going to go first to a couple of specifics that came to my attention as I was going through this material.

In your comments, within the analysis, on Page 3, you say, "The DOE statement about its role and the technical aspects of the battery"—we are talking about the battery technology—"appear supportable. However, DOE neglected to state that the battery's feasibility has not been demonstrated."

But, yet, I find in this GAO document put out in August of 1995, I read, "As of mid-1995, most aspects of technical feasibility has been demonstrated for one mid-term battery technology."

Mr. LI. Okay.

Ms. RIVERS. So, I am not clear——

Mr. LI. Okay. I would like to, in a way, provide some background for the other members that understand that this particular document—and I'm not moving away from the validity of the document that you reference. The document you reference was a document which I used to brief the Department of Energy on why I came to those conclusions on that particular table.

That was not a document that was attached to the report that the Chairman received on Monday. So, I just—for the record, I just wanted to establish that.

Ms. RIVERS. Okay. And, I also wanted to point out that on April 8th of 1996, Honda released a press release saying that they will now be—announced today it plans to be the first automaker to market an EV using nickel metal high dried batteries. So, the technology is in the market.

Mr. LI. The—I'm sorry. The point I would like to make is the following:

We are talking about—and I think both we and DOE agree that the technological issues have been resolved in terms of the metal high dry battery. The issue we were talking about was the marketability of that particular battery.

At $7,500, the issue that we had was that we didn't think—and the automakers would agree with that—that it would not be marketable and would require substantial subsidies.

Ms. RIVERS. Honda putting it out on the market.

Mr. LI. Okay. I am not familiar with that document.

Ms. RIVERS. I looked back when you mentioned the methodology and what you believed your charge was. And, you said it was determining whether or not the documents were here to support the claims.

But, on reading from the letter GAO sent back to John Kasich, it says, "Specifically, you asked us to determine whether [1] the claims that DOE makes in the report are valid; and [2]," which is a different issue altogether—but, yet, what you are telling me that you believed your charge was is that it was your job to make sure the claims were supported.

Mr. LI. That was with our understanding. And, we explained that to Mr. Kasich, is that that was going to be our methodology that we would use to respond to that particular question.

Ms. RIVERS. Then, why does the letter not use that terminology? I mean, it seems like what you are saying is it's the old math test. If you don't show your work, whether the answer is right or wrong, you don't get credit.

Is that a fair way to characterize it?

Mr. LI. Well, I think it's a fair way to characterize it. What we did, in order to establish the validity of those particular numbers, is to see whether or not DOE had the documentation behind that.

In the amount of time that we had, had we gone through a large analysis, we would probably have to go through things like looking at what would be the demand and supply issues associated with each one of those products. We would have to, for example, look at the validity of the models that DOE had actually used.

Ms. RIVERS. So, you didn't actually test the claim. You tested whether everything to get to the claim was done correctly?

Mr. LI. That's right. We——

[The following information was received for the record:]

[We] ... contacted the officials in the appropriate DOE research program offices who were responsible for the individual projects and obtained and evaluated the supporting documentation provided for each use.

Ms. RIVERS. So, that was an irrelevancy, whether the claim was true or not.

Mr. LI. What we tried to find out is whether or not there was substantiation to the numbers that DOE had in the "Success Stories" report.

Ms. RIVERS. The other area I want to ask you about is in a couple of places you mention—one is the AC electric train drive and the other, the heat engine component. You make reference to the fact that the DOE is somehow suggesting that they had something to do with the creation of the California mandate.

I went back and read specifically the language in both of those paragraphs. And, I would like you, for the record—you don't have to deal with it now, but for the record put down specifically what you meant, because one says "California laws mandating zero emission will result in" and the other one says "as the result of the mandates for zero emission vehicles will." And, so I would like to see the specific language.

The last question I have is that, as we have found errors in this document, I am curious to know GAO's perspective on that, because in my neck of the woods we build cars. If you send a car out on the road and you find out there is a mistake, you recall the car and you fix it.

And, so I'm interested in knowing if GAO is going to take the document back and make some changes that will address the issues that have been raised by individuals here and the DOE.

Mr. LI. We take all concerns that have been expressed seriously. And, I don't know—I can't identify whether or not that will be in the form of a retraction or another report.

I can tell you that the concerns expressed today I take very seriously. And, I will review all of those.

Ms. RIVERS. Okay. Thank you very much. Thank you, Mr. Chairman.

Chairman ROHRABACHER. Thank you very much, Ms. Rivers. Just to clarify any questions people have in mind about any questions the Chair has raised with the Department, we received our budget request obviously late this year. The President was late by a number of weeks, six weeks and seven weeks late, with his budget request.

And, the budget request was less detailed than we have received in past years. Thus, there has been a number of questions that the Chair has put forward as well as, for example—and, as we heard today, Ms. Ervin didn't know how many political appointees we are talking about.

We have to ask these types of questions. It was not in the budget request.

For example, one of the questions asked was the number of noncompetitive contracts which have been issued by the Department. And, I believe that's a legitimate question that needs to be asked.

As well as, for example, there were budget requests for things like the vision programs, the glass and aluminum vision programs, without much of an explanation, I might add, of what those programs were. And, so as far as we are concerned, I mean, that's perfectly legitimate.

And, I believe that our number of questions asked is maybe more than it was last year but it may not be out of line with the total number of questions asked by this Committee of the Executive Branch in years past, especially, as I say, when this Committee was held by one party and the Executive Branch was the other party in years past.

Now, as a matter of courtesy, I would like to extend an offer to the distinguished former Chairman of the Science Committee to ask any questions now that he would like to ask.

Mr. BROWN. Thank you, Mr. Chairman. You are unfailingly courteous to us senior citizens. And, I appreciate it.

[Laughter.]

Mr. BROWN. But, I will waive my right to questions for the time being.

Chairman ROHRABACHER. Thank you very much, Mr. Chairman. And, now to Mr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman. I am approaching senior citizen status, and I hope that in a year or two I will get that courtesy as well. Thank you.

I just wanted to observe, first of all, that I don't think any part of the DOE budget is more important to the long term economic health of this nation than the budget we are talking about here. And, I think that's extremely important for all of us to recognize.

I would comment just to reflect that this is a bipartisan issue when we talk about energy. Mr. Roemer's comments about the GAO report I thought were right on.

I am not trying to give you a rough time, Mr. Li, or denigrate the GAO, because it's an outstanding organization and you have an excellent record. I just don't think this particular report was up to the usual standards.

And, I would hope that you would just consider those comments. I don't expect you to respond, but I hope you would review the document again.

And, Ms. Ervin, in regard to that same issue, I would like to ask that you issue a revised edition of "Success Stories" that takes into account the GAO comments and perhaps work with Mr. Li, because what we are interested in here are the facts and not opinions. And, we are interested in getting a document that reflects the facts.

So, if you—and I'm sure you are working on that already. But, I just want to say that I would be very interested in that. And, I would appreciate the GAO once again looking at this issue and trying to give us, as objectively as possible, what the situation is.

I would—go ahead.

Ms. ERVIN. Yes. Joe Romm, who has been our principal investigator on this and who has worked closely with the General Accounting Office over the last seven months, advises me that we have already made that offer. We would like to work closely with you on this.

I do feel that our major concern with the report, as it now stands, is that it does not qualify the nature of the methodological differences and separate that very distinctly from the not disputed substantial benefits.

Mr. EHLERS. Yes. And, I recognize that point.

Ms. ERVIN. And, we would be happy to——

Mr. EHLERS. But, I am saying I would like a final document——

Ms. ERVIN. Yes.

Mr. EHLERS. A final version of "Success Stories" that is accurate, that reflects the facts and that is essentially acceptable——

Ms. ERVIN. Good.

Mr. EHLERS. (continuing) to the GAO as well in terms of methodology and accuracy.

Ms. ERVIN. We have a letter from my colleague, Patricia Godley, and I and Mark Chuka, who is the Acting Assistant Secretary for Policy, we have a detailed letter with all of our comments and our offer to do just that. And, I would like to submit it to the record, please.

Mr. EHLERS. Thank you. I assume, Mr. Chairman——

Chairman ROHRABACHER. Without objection. I'm sorry about that.

Mr. EHLERS. Thank you. The other observation that I would like to make and part of the reason that I believe the nation and the public don't realize the importance of your activity in this part of the budget is something I've encountered many times over the years in talking about energy issues. Energy is not a material entity.

And, it is very difficult to communicate to the public any aspects of energy, particularly the laws of thermodynamics, which I know that you and a number of members of the audience understand, but talking to the general public can be very frustrating.

I've always said that in my retirement, I will write a book about energy and I'm going to entitle it, "I Wish Energy Were Purple," because if, in fact, energy were purple and we could see it, we would not have the energy waste problem that we have in this country. We would have much greater energy efficiency.

And, the sad part about it is that energy is so foundational to our economy and most of the nation, including a good many economists, do not recognize that. And, that's why the work is so important and that's why it's extremely important that we have accurate information so that we, together with you, can make appropriate priority decisions.

As the Chairman pointed out a moment ago, that's our job here. That's also your job. And, we need the facts in order to make those priority decisions.

I know what my priorities are. But, if we are going to do them as a group, we have to have that information.

Thank you very much. And, I yield back, Mr. Chairman.

Chairman ROHRABACHER. Thank you very much. Mr. Olver.

Mr. OLVER. Thank you, Mr. Chairman. As usual, I would like to associate myself with the comments just made by the gentleman from Michigan and thank him for them.

I suppose we have flogged the horse of the "Success Stories" and the GAO report, but what the heck. I might as well add a little bit to it.

[Laughter.]

Mr. OLVER. I would like to understand here. As I understand it, the report itself, the "Success Stories," covers 61 of the technologies that have been worked on.

Could you tell me, Ms. Ervin, how many roughly technologies are we? In the hundreds or the thousands in the total number of technologies that have been—that might be listed as—that have been developed or supported?

Ms. ERVIN. If we look back over since 1978, we are probably talking thousands.

Mr. OLVER. Probably thousands? So, your report is on 61 of them.

And, then, am I correct that the GAO report, you looked at a portion of the 61, if I remember, 15 of them.

Mr. LI. Yes, sir.

Mr. OLVER. Were those chosen randomly? Are they the largest ones, the smallest ones or what?

Mr. LI. No, sir. In the report, we identify the fact that those 15 that we chose really account for a majority of the benefits associated with the claims that DOE makes.

So, when we chose them, we also chose them that they represented across the board. They weren't only in one particular area.

We have the renewable, the efficiency ones. We also have some that deal with other energy aspects like the light water reactor.

So, that is identified in the report, sir.

Mr. OLVER. But, among the 15, the things like the ballast and the energy efficient windows, which are a couple of the major successes, those were included in what you——

Mr. LI. Yes, sir.

Mr. OLVER. (continuing) reviewed?

Mr. LI. Yes, sir. And, they were because——

[The following information was received for the record:]

[Yes sir. And, they were because] ... we selected a sample that included cases representing a cross-section of DOE's applied research programs and cases that cited large benefits.

Mr. OLVER. My understanding—am I incorrect? Did I not hear or maybe it's partly heard and partly read that in each of those cases it was only several million dollars and clearly identified several million dollars of investment in R&D on the part of the Department of Energy in each of those cases?

Mr. LI. In those two, yes, sir.

Mr. OLVER. In those two?

Mr. LI. It was identified in the report that up to the 80s they spent $3 million on one of those technologies. I can't recall which one, sir.

Mr. OLVER. So, your contention is that they have not—that they only included a certain block of time and not the whole of the—what did—are you claiming that they claimed the benefits up until the present time but costs only up until a certain time?

Mr. LI. No.

Mr. OLVER. I mean, it's a little hard to follow this.

Mr. LI. That's fine. The issue that we are making, the larger issue, is that all costs—and I think that the chart that DOE put up really reinforces my point.

Mr. OLVER. Reinforces your point rather than their point?

Mr. LI. I point out the need to identify costs versus benefits associated with each one of——

Mr. OLVER. I don't know how that could reinforce that, because it does not—it does not break down into what are the costs in each one of the places, the chart as it is. So, I don't know how———.

Mr. LI. That's what I'm saying, sir.

Mr. OLVER. But, how could they know what point you were trying to—you were going to make out of it?

Mr. LI. Okay. My point, if I may, is that here are the most successful ones that the Department has identified. I think that the entire portfolio needs to be identified in terms of knowing whether or not we've made a prudent investment.

And, that is my point.

Mr. OLVER. Well, the two major conclusions appear to be in your summary. I assume those are the major conclusions, that the benefits in many of the cases are not—the benefit analyses are faulty with a variety of errors, number one.

And, number two, because it describes—it is invalid as a measure because it describes the successes of a small percentage of the total number of projects.

Mr. LI. That's the second point, sir.

Mr. OLVER. That's the second one, number two. Those are the correct ones.

And, indeed, we are dealing with 60 out of——

Mr. LI. Sixty-one out of a few thousand.

Mr. OLVER. (continuing) say, more than a thousand, a large bread box. So, may I just ask, would you give me your sense of the validity of that, of the two major conclusions again, Ms. Ervin?

Ms. ERVIN. If I might, I really would like to invite Joe Romm, my Acting Principal Deputy, to the table, because he has worked so closely with the GAO on this report. And, I suspect he has some nice contributions to make to your question. May I?

Chairman ROHRABACHER. You have only got 20 seconds.

Ms. ERVIN. Talk quickly, Joe.

Mr. ROMM. Yeah, Dr. Joseph Romm. Let me just be very brief. I am delighted that Mr. Li has conceded that there are mistakes in the report and that he seems to be backing away from the supporting analysis on which the report is based.

Let me just state for the record that the report states, "None of the case studies we evaluated discuss how much DOE spent on its R&D efforts supporting the technology." None.

And, Mr. Li just said that two of them did, for the record. We would hope that an errata sheet would accompany the GAO report in the future.

Chairman ROHRABACHER. Okay. Mr. Olver, your time is up. And, thank you very much.

But, because Mr. Li seems to be the target of so many of these questions and whereas something—Joe just mentioned something that I think Mr. Li deserves a chance to comment on, I think we will end your session by giving him a chance to just answer what was just thrown in his direction.

Mr. LI. The point that I was making—while you can quibble with the "none" or whatever, I think the larger point is when you are talking about providing costs and benefits, the majority of the high cost ones—we are talking about the $3 million ones—they spent $1 billion on photovoltaic, they spent $1 billion on light water reactors. I identified the fact that what my conclusions were.

I respectfully disagree with my friend from DOE that I have conceded that I have made mistakes.

Chairman ROHRABACHER. Well, I thought that——

Mr. OLVER. I thought the mistake had been absolutely identified.

Chairman ROHRABACHER. Let me note that Mr. Li is not conceding that he has made a mistake. At least, that's what you are saying; is that correct?

Mr. LI. Yes.

Chairman ROHRABACHER. Anyway, Mr. Li, you are not conceding that your report was in error?

Mr. LI. No.

Chairman ROHRABACHER. Okay. Thank you. Now, Mr. Wamp.

Mr. WAMP. Thank you, Mr. Chairman. Ms. Ervin, on the energy and conservation accounts, 32 percent increase, I think, in the President's budget from 1996 to 1997.

Why not just level funding? Just in a layman's explanation, why couldn't we just level this account out and support level funding for this program?

Ms. ERVIN. This is level funding with the 1995 appropriations. The President's budget for 1996 was considerably higher than the expected outcome, so it is level to 1995.

We are trying to stabilize funding for these programs. The funding for energy efficiency and renewables over the last 15 years has been very erratic.

It places a great hardship on our ability to do good, sound business planning with our partners. And, bringing it back to the 1995 level, I think, is appropriate and clearly in line with the returns on the investment that we are making.

Mr. WAMP. And, just explain the 17 percent reduction in fossil energy on the request for the record.

Ms. ERVIN. I would like to leave that to my colleague, who is coming up next, Pat Godley.

Mr. WAMP. Okay. For the entire panel, I reference the "Atlantic Monthly" column that Secretary Curtis wrote not too long ago at a hearing that we had.

And, in that article, it says, "Imagine a world in which the Persian Gulf controlled two-thirds of the world's oil for export with $200 billion a year in oil revenues streaming into that unstable and politically troubled region and America was importing nearly 60 percent of its oil." My question is. How much of our U.S. trade deficit is directly linked to our oil exports and how far off is this scenario that this article illustrates?

Is it a legitimate national security issue, how much oil we are importing from the Middle East?

Ms. ERVIN. Since we have one of the co-authors, there again, Joe Romm, I would ask him to speak to your question.

Mr. ROMM. Oil is getting up to be about half of the merchandise trade deficit. Presumably, we are working on efforts to reduce other elements of the merchandise trade deficit.

In the scenario that's described in the article, it's 10 years away. According to the Energy Information Administration, at that time the trade deficit in oil would be $100 billion. U.S. import dependence would be nearly 60 percent and world dependence on Persian Gulf oil would be its highest level ever, perhaps around 70 percent.

Mr. SCHIFF. Would the gentleman yield for one second?

Mr. WAMP. I would be happy to yield to Mr. Schiff.

Mr. SCHIFF. I appreciate it. And, by the way, Mr. Chairman, thank you for accommodating me before. I've taken care of other matters.

I seem to remember in a previous Congress voting for an energy policy that was supposed to reduce our dependence on foreign imported energy. And, I wonder if briefly someone could say why we are looking at such an increase in this curve again. I thought at one point we were supposed to have taken care of that.

Mr. ROMM. Well, the—among the reasons would be the fact that in the 1980s the budget for renewable energy was cut around 90 percent and the budget for energy conservation was cut about 77 percent. So, we did have a variety of strategies to use oil more efficiently and come up with substitutes when the budget was cut.

Mr. VOLKMER. Would the gentleman yield, the gentleman from New Mexico or the gentleman——

Mr. SCHIFF. It's the gentleman from Tennessee——

Mr. VOLKMER. I think I can answer it—

Mr. WAMP. I will be happy to yield to Mr. Volkmer——

Mr. VOLKMER. (continuing) very easily.

Mr. WAMP. (continuing) as long as I can finish my statement. Go ahead.

Mr. VOLKMER. Well, we started the energy efficiency programs and tried to get other renewable energy and stuff back under President Carter and then we got another president after '80. And, everything went poof, just like that.

[Laughter.]

Mr. VOLKMER. That's what happened to it, if you want to know the truth.

Mr. WAMP. Reclaiming my time——

[Laughter.]

Mr. SCHIFF. I do want to thank the gentleman from Missouri for the most succinct explanation on policy questions I've ever heard.

[Laughter.]

Mr. WAMP. One other issue. I commend to everyone here, while I have a moment, a new show that I saw previewed last night on the ecology channel called "A View from Moccasin Bend" about the City of Chattanooga, which has absolutely gone from one of the dirtiest cities in America to one of the cleanest cities in America and is promoting the notion of sustainable development. And, it has become a living laboratory.

And, it's incredible. And, it's a testimony to my conservative friends of how this can be done when industry goes the extra mile with a decent set of minimum regulations.

I commend it to you, but along those lines I also—and you know I will defend a lot of the DOE programs as we go to markup next week, but I want to say this, because there is apparently some messages coming from downtown about the Republicans not going far enough on corporate welfare. Yet, our transportation programs here in this budget are pretty heavy towards the Big 4 going into the energy efficiency business by creating cleaner vehicles.

And, by the way, we are building those in east Tennessee and competing with Detroit on buses. And, we will get to cars. And, so we are doing it real well.

[Laughter.]

Mr. WAMP. But, I want to point out that let's not throw too many rocks here, because there can be marriages between the private and public sector. And, some of it is legitimate.

And, so let's not just say, "You guys are bad and we are good." I mean, we are both some bad and we are both some good, but we ought to come together on some of these things.

And, the Big 4 ought to look for alternative ways to build automobiles that are cleaner and have a life cycle responsibility. And, I know Ms. Ervin wants to comment on that.

Ms. ERVIN. I do. One of the major thrusts that you are referring to is our partnership for a new generation vehicle. And, that is with Detroit.

But, also the supplier chain. We often forget that 75 percent of the money that's going to the partnership for new generation vehicle is being passed through the three automobile manufacturers to suppliers, laboratories, universities and so forth.

It's an important effort. It has a lot to do with what that curve is going to eventually look like, that and alternative fuels. And, it's a serious effort.

This is a good case where the private sector does not have the immediate price incentives or economic incentives to care about our national deficit, to care about our trade deficit. We've got joint interests here, a marrying of private and public interests.

And, I'm truly proud of that partnership.

Chairman ROHRABACHER. Thank you very much. Your time has lapsed.

Mr. Doyle had to leave the room and now he is back. And, so he is in line.

I would just like to remind Mr. Doyle that while he was gone, Mr. McMahan said some wonderful things about one of his favorite subjects, which is coal. And, you go right ahead, Mr. Doyle.

Mr. DOYLE. Thank you, Mr. Chairman. Mr. Li, I recall you using a football analogy when you started your testimony to Mr. Largent. And, I guess I'm going to use one, too. It's called piling on.

[Laughter.]

Mr. DOYLE. And, I am going to ask you a few more questions. You know, it's okay to make mistakes. We make them all the time up here.

And, just in looking at the GAO report—and I don't know how much was covered by this report or not, but is it your testimony—because I did miss some of the replies—that there are no mistakes in this GAO report? You have not acknowledged any mistakes in this report?

Or, maybe I misunderstood you.

Mr. LI. I would like to clarify that.

Mr. DOYLE. Okay.

Mr. LI. The fact—I disagree with—I think the word, "mistake," that's where I'm coming from. I think that the document that we have written, the thrust of our message was the overall cost versus benefit.

If you focus only on that single word—and it's like when I counsel my son and I tell him something, he uses—he pulls out one of those individual words.

Mr. DOYLE. Kids are good at that.

Mr. LI. He says, "But, Dad, you didn't say that." And, my overall thrust was the overall costs and benefits.

If you focus only on the word, "any," I think that, yes, you could misinterpret that I only meant—I said everything and there wasn't that $3 million. It's black and white. It's in there.

My overall point was all costs. And, even the costs associated with one of those technologies only limits it to saying this is how much we spent up to a certain amount of time.

What I was trying to tell Mr. Olver was that I think that all of these technologies should be identified on the same basis for how much money they've spent up to a certain time so you can compare that with what benefits are associated with that. That's kind of what I was saying, sir.

[The following information was received for the record:]

Mr. Romm pointed out that two of the fifteen case studies had listed a DOE investment figure. I disagree that this issue should be framed in the context of a "mistake."

Mr. DOYLE. But, what I want to understand is you are not suggesting to this Committee, though, that—I mean, if you look at the cost benefit ratio, for the amount of money that we've invested in these programs, you are not disputing that there has been great benefit far exceeding the costs of these programs?

Mr. LI. For the ones that we showed, yes.

Mr. DOYLE. Overall. I mean, if you look at the whole, at——

Mr. LI. I don't know what overall——

Mr. DOYLE. If you look at every dollar we've spent in this area and if you adjust for inflation—and I want to adjust for inflation, because I don't want to make a math mistake here. So, if you adjust for inflation, we are talking about, what, $7 billion of investment here in federal dollars and benefits that far exceed that, maybe $44 billion just in one project alone after we've corrected the math mistake there, in addition to $7.9 billion in energy savings and $8 billion in foreign and domestic sales.

I mean, can there be any—even the slightest inkling of the dispute that taxpayers have been very well served by these programs and that the Department of Energy has clearly met its mission in this regard?

Mr. LI. My position was I thought that it would be more prudent and it would make sense from a stewardship perspective that if you knew what you were investing in—and I'm not disputing your claim that there are a lot of benefits and the ones for the examples that DOE has explained to you, that there are a substantial difference between the two.

Mr. DOYLE. But, could you just give me a simple answer to my question? Is there any dispute that for the money we've invested in total——

Mr. LI. I do not know what that total is, sir. If I knew what that total was——

Mr. DOYLE. Seven billion dollars adjusted for inflation, $7 billion when you adjust for inflation. And, the return I just outlined.

Is there any dispute that this is a hell of a good deal or a heck of a good deal?

[Laughter.]

Mr. DOYLE. Or a good deal?

[Laughter.]

Mr. LI. If the total is $7 billion, which I have not looked at—and this is—I have to apologize; I don't know what that total is—it would seem that it would be a prudent investment. However, sir, I would like to say this, in that the focus in the R&D program—and, if I may, I would kind of like to explain this other point.

I think one of the difficult things in research and development is that we don't have a good set of measures to establish what we should be putting money in. And, I think this points out the dilemma that decision-makers have in terms of not being able to have what those measures are.

Obviously, being able to identify a difference between costs that we get out of the investment and the benefits is a good one. But, there's many different types of benefits in this particular success story.

For example, some of the—may I continue?

Mr. DOYLE. Oh, you—please continue.

Mr. LI. Some of the benefits are identified in terms of energy savings. Some are identified in terms of market sales.

I would like to say that somehow we need to not compare apples with oranges. And, I would like to be able to eventually get to that point.

And, I just wanted to say that that is a difficult dilemma. And, I'm not saying DOE should be the one to do it.

I think that's an overall perspective that the nation should be looking at.

Mr. DOYLE. Mr. Chairman, I know I'm at the end of my time. I just conclude by saying, Mr. McMahan, I'm going to submit some questions for you in writing.

And, I think when you look at this overall portfolio, it's quite clear taxpayers have been well served.

Mr. ROMM. Could the Department make a statement for the record? I think——

Chairman ROHRABACHER. If you could hold on, we've actually exceeded our time right now. And, I'm sure one of the other panelists will be happy to ask you a question that will give you a chance to put that on the record, whatever thought that is, Joe.

Mr. Bartlett.

Mr. BARTLETT. Thank you very much. Can you tell me what percent of electricity, of our electricity, is now produced from oil?

Do you have those numbers, that percentage?

Mr. ROMM. A few percent.

Dr. MCMAHAN. It's about 3 percent. It's 3 percent from oil. It's residual oil from the refineries. It's essentially a byproduct of the refining process.

Mr. BARTLETT. And, I understand that 20 percent of our electricity is now produced by nuclear plants?

Dr. MCMAHAN. Yes.

Mr. BARTLETT. My question gets back to a question that was asked by my colleague, Mr. Schiff, and that is about an energy policy. With what are we going to replace—where will we get that 20 percent of energy from when we no longer produce nuclear energy?

And, we are clearly headed in that direction. We are not licensing a single new nuclear plant. And, in the early part of the next century, most of the plants that are now in operation will reach the limit of their license and are likely not to be relicensed.

We now get roughly 50 percent of our oil from overseas. As you indicate, that is going to rise to 60 percent.

I think that it is a matter of national security interests. And, as an energy policy, where are we going to get the additional electricity production that we are now getting from this 20 percent that is nuclear?

Dr. MCMAHAN. There will be a mix that will primarily come from—it will primarily come from state-of-the-art coal and natural gas generation. And, there will be gains, we believe, in renewables.

I think the key questions that people need to wonder about, though, on fossil versus renewables is not so much photovoltaic and wind, those sorts of things, but more the tradeoff between burning fossil fuels versus growing trees to burn them, which I think is another policy issue that I'm sure the Committee will deal with.

The word, "renewable," has to—people have to understand that all renewables aren't photovoltaic and wind. That's a very small portion.

But, there is plenty of domestic supply of energy for electricity. I don't think there is any question among economists or energy companies about that.

Mr. BARTLETT. But, we need to plan so that we are sure that we can replace that.

One other consideration as a policy consideration relative to oil and gas, they are now the basis of an enormous petrochemical industry. As my colleague, Dr. Ehlers, says, oil and gas are probably too good to burn, you know.

What is our policy for replacing gas and oil as a basis for this enormous petrochemical industry if we use it all for its lowest productive use, which is energy?

Dr. MCMAHAN. That should probably go to the DOE. But, there are a number of other carbon-based fuels—coal and natural gas obviously.

There are questions about how long the supply will last, how big the gas bubble is. You know, time will tell on that front.

There's very little question about integrated gas combine cycle capabilities and the petrochemical byproducts that come from that. I don't know of anybody that worries about the availability of that resource domestically, frankly.

Mr. BARTLETT. That may be our problem, that nobody is worrying about it.

[Laughter.]

Mr. BARTLETT. I thank you very much.

Mr. EHLERS. Will the gentleman yield?

Mr. BARTLETT. I will be happy to yield.

Mr. EHLERS. You said you couldn't tell how long this would last. I think almost anyone will tell you that 30 years down the pike it's going to be exorbitantly expensive because of the scarcities we are going to have at that time in oil and natural gas, which is the most readily available.

Coal obviously can be used for raw material for the petrochemical industry.

Dr. MCMAHAN. Exactly.

Mr. EHLERS. But, that has a great deal of undesirable side effects—both difficulty of handling, the large number of toxics produced, the huge amount of waste that comes out of that and so forth. So, I just wanted to get that on the record as well.

And, I certainly support Dr. Bartlett's comments on that.

Mr. BARTLETT. Well, thank you. And, just one other additional comment, Mr. Chairman.

As we move increasingly to coal as an energy source, because we are now probably on the down side of pumping our oil, every year since the 1970s, in spite of aggressive exploration, we have found less oil and pumped less oil than we did the year before. And, there's some pretty good evidence we are on the down side.

We have now used more than half of all the oil we have. Until the Carter era, every decade we used as much oil as was used in all of our previous history.

Fortunately, we have now broken that cycle. And, we are using somewhat less each decade than we used in all of our previous history.

But, as we move increasingly to coal, there are increased environmental penalties that one pays for doing that. One just can't say that we will go to coal because there's a lot of that as compared to oil, because there are enormous penalties associated with doing that.

I'm concerned that we do not have a well articulated national policy that will take us from where we are to where we obviously are going to need to be in 30 to 50 years from now. And, we are going to see some of the leading edge effects of that far sooner than the 30 to 50 years from now.

Thank you very much, Mr. Chairman. I know my time is up.

Chairman ROHRABACHER. Thank you, Mr. Bartlett. Mr. Volkmer.

Mr. VOLKMER. Mr. Li, I will make a comment here. The way I see your testimony is that if I were to give $100,000 to my stockbroker to invest and he invested it in 100 companies and 99 of them went broke and the other one company made me $1 million, you would say I have to analyze the other 99 before I can figure out whether I made a profit or not.

Mr. LI. Sir, I'm not a—I don't play the stocks, so I——

Mr. VOLKMER. I know that.

[Laughter.]

Mr. VOLKMER. But, that's just what you did when we are talking about this. It's the same thing.

Forget it. Just forget it. Forget it, Mr. Li. Just forget it. Some people are just too dense.

Ms. Ervin, you have been provided, DOE, a list of all these whatever, number of questions, from the Chairman and the staff. How long will it take you all and how many man-hours is it going to take to file an answer to approximately 569 questions?

Ms. ERVIN. In the—just to clarify, we received a total of about 800 questions.

Mr. VOLKMER. All right, 800 questions. How long is it going to take?

Ms. ERVIN. I don't know. We are working hard on it, I will tell you.

And, I would be afraid to make an estimate. It could be months.

Mr. VOLKMER. I mean, it can't be tomorrow or next week?

Ms. ERVIN. No, it cannot possibly be.

Mr. VOLKMER. And, if we go to markup next week on this, the answers to these questions is superfluous; is that correct?

Well, you don't have to answer that. I will answer it.

[Laughter.]

Mr. VOLKMER. It's superfluous. Now, let me ask you this. How do you answer this question? How does anybody answer this question?

Please provide a listing of recipients for the requested level of $9,886,000 in Fiscal Year 1997 for IEC's technology transfer.

Do you know now who is going to get the money for Fiscal Year 1997?

Ms. ERVIN. No. Many of our projects are competitively bid. You are correct. So, there is no way of anticipating that.

Mr. VOLKMER. So, do we have to wait until the end of 1997 to answer the question?

[Laughter.]

Mr. VOLKMER. I think you should.

[Laughter.]

Mr. VOLKMER. I think the best thing to do is to answer the question truthfully, you should wait until the end of 1997 and then give the Committee those answers.

Ms. ERVIN. Thank you for your suggestion.

Mr. ROEMER. Mr. Volkmer, would you yield for just a quick question?

Mr. VOLKMER. Yes, I will yield.

Mr. ROEMER. Just in comparison, Secretary Ervin, how many questions would the Democrats submit to you when you were in this position or your predecessor in a position like this?

Ms. ERVIN. Who has an idea? I'm going to turn to some of my career management team people.

Much fewer. I hear about 300 or 400.

Mr. ROEMER. 300 or 400 as opposed to 589? Thank you.

Mr. VOLKMER. Eight hundred and some. It's over 800 now.

Ms. ERVIN. We are going to make a conscientious effort to try to provide useful information. I will tell you—I will give you a couple of examples, though, of things that are difficult for us to respond to.

One of the questions, for example, is: "On Page 459 of Volume 2 of the Congressional Budget request, it is stated that an independent commission headed by Energy expert, Daniel Yergin, confirmed," et cetera, et cetera. Question A is, "Please explain why the Secretary of Energy Advisory Board Task Force, chaired by Daniel Yergin, was a commission."

We will answer that. But, it's difficult.

Mr. VOLKMER. Now, what does that have to do with energy policy, though? What does that have to do with any markup?

Ms. ERVIN. There is——

Mr. VOLKMER. There is no question, it has nothing to do with it, nothing to do whatsoever. And, a good many of these questions have nothing to do.

It's pure harassment. That's all it is. And, I think it's almost an abuse of the legislative authority that some people have at the present time.

I will yield to the gentleman from Pennsylvania if he has any additional questions.

Mr. DOYLE. Thank you. I just wonder—we hear a lot of talk on this Committee, too, and I don't know if it has been touched on before or not, about corporate welfare.

And, I wonder, Ms. Secretary, if you could just take a couple of minutes and tell us, you know, if you think programs like the clean car initiative and others——

Chairman ROHRABACHER. Maybe she could take 30 seconds instead of a couple of minutes.

Mr. DOYLE. Thirty seconds to talk a little bit about this accusation of corporate welfare in the Department.

Ms. ERVIN. Well, the quickest way of doing it—and I can put it in the clean car initiative context—is to use a frequently repeated definition provided by the Cato Institute. And, that is, "We define corporate welfare as the use of government authority to confer special benefits and privileges to specific firms or industries where there is no corresponding societal benefit."

We are not in the business of corporate welfare. Clean car is a perfect example of where there is a compelling overwhelming societal need that the private sector has no incentive to meet on its own.

That's the kind of partnership we have. And, it doesn't meet the definition of corporate welfare.

Chairman ROHRABACHER. Thank you very much. Your time is up.

I would just—first of all, I think Mr. Li has gone under a lot of abuse today. And, let me just say that I don't believe that it's appropriate for people on this Committee to be commenting about Mr. Li's mental capabilities.

And, I think that a side comment was made during—by the last questioner which reflects very poorly on his judgment. And, Mr. Li, we have nothing but——

Mr. VOLKMER. Would the Chairman yield on that?

Chairman ROHRABACHER. I certainly would yield. Go right ahead.

Mr. VOLKMER. My judgment or Mr. Li's judgment?

Chairman ROHRABACHER. I think it reflects very poorly on the judgment of a member of this Committee to comment on Mr. Li's mentality, calling him dense.

Mr. VOLKMER. All right, fine.

Chairman ROHRABACHER. And, I think you owe him an apology.

Mr. VOLKMER. Not until you apologize for what you've done to the Department of Energy.

Chairman ROHRABACHER. Mr. Li, let me just say that there are many members of this Committee on both sides of the aisle who don't believe that being discourteous to a witness, as you have been treated today by at least one of the members—tough questioning is certainly part of these hearings. I mean, tough, adversarial questioning is what you expect.

And, you've been put through a lot of very proper, tough questioning by people who disagreed with what was in your report today. But, let me just say that it is not the policy of this Chair to sit by and allow people to basically call our witnesses names.

And, I think it was totally inexcusable. And, someone who is doing that shouldn't ever use the word "harassment" in terms of what someone else is doing.

We would now move on to Ms. McCarthy from Missouri.

Ms. MCCARTHY. Thank you, Mr. Chairman. I would like to request that in addition to the testimony submitted by Mr. McMahan that two publications which speak to that testimony and report be included in the record.

One is from the National Renewable Energy Laboratory and the other the National Wind Coordinating Committee. And, they do speak to the report.

And, I would like to have them submitted for the record.

Chairman ROHRABACHER. No objection.

Ms. MCCARTHY. I would like to yield the balance of my time to Ms. Rivers and to Mr. Doyle.

Ms. RIVERS. I will take just a moment. I had planned on making this comment before the Chairman just spoke, but I will also add that I want to make it clear, particularly to Mr. Li, that while I have concerns about this particular report and how it was handled, my experience with GAO, in general, has been very positive.

We rely heavily on their work. I use it in preparing materials for my constituents and educational work that I do all across my district. And, I hope to continue to do so.

And, while I disagree with this particular document and hope that you will make changes, I do not think it casts dispersions on you as an individual nor on the agency as it exists. And, I hope that you will come to us under more pleasant circumstances in the future.

Chairman ROHRABACHER. Mr. Doyle, do you have any other questions?

Mr. DOYLE. Thank you. And, I thank the gentle lady from Missouri for yielding me some time.

Mr. McMahan, I just wanted to get a chance to ask you a question, too. I come from Pennsylvania. There is a fair amount of coal in that state.

And, you know, when we talk about looking into the future and what our energy needs are going to be and the fact that there is still going to be a great need—fossil energy is still going to constitute 88 percent of our energy use, it seems to argue in favor of not falling back on the federal commitment to coal R&D research, because one of the challenges with coal, of course, is to find ways to burn it cleaner and cheaper. And, this becomes an abundant source of energy for the country and a dependable source.

And, I just wonder if you could take a couple of minutes—and I'm sorry I missed your testimony—to talk a little bit about what you would see as areas we should explore in coal R&D in the future?

Dr. MCMAHAN. Well, I think clearly the coal industry and all fossil industries have demonstrated that they have increased their efficiencies substantially, moving from roughly 30 percent conversion efficiencies up into the 40 and hopefully 50 percent level. Those technologies—even though they are not growing in the United States, those technologies are actively being exported.

It's U.S. technology now that's building the major coal-fired power plants in Indonesia, Malaysia, India. And, as that technology, then, further develops offshore, I'm sure that those advances will move back.

And, you know, I mean, clearly while we are not importing oil for electricity, we certainly are exporting our electricity capabilities and generating capabilities overseas.

Mr. DOYLE. Thank you very much, Mr. McMahan. I yield back my time, Mr. Chairman.

Chairman ROHRABACHER. Mr. Chairman, Chairman Brown, would you like to ask any questions now?

Mr. BROWN. Mr. Chairman, thank you. Thank you very much for your consideration.

I would like to ask unanimous consent to insert a letter at this point in the record that I sent to the head of the GAO today with regard to this report.

Chairman ROHRABACHER. It's without objection.

And, we will just have a short summary, Mr. Roemer. And, then I will give a short summary. And, then we will be on to our next panel.

Excuse me. Joe, did you get your chance? You wanted to put something in the record.

Is it shorter than 30 seconds?

Mr. ROMM. I will try to do it in 30 seconds.

Chairman ROHRABACHER. Go ahead.

Mr. ROMM. I very much appreciate the Chairman's forbearance.

Chairman ROHRABACHER. Without objection, we are going to give Joe his chance to get his words in.

Mr. ROMM. When the GAO's mistake was pointed out by Ms. Rivers, by myself, they said that that was a quibble and that we should just look at the thrust of our message, that we shouldn't pull out an individual statement because you could misinterpret it, that you should focus on our overall point. The Department of Energy would have liked the same view of our "Success Stories."

We feel that they have taken things out of context. They have willfully misinterpreted.

They have focused on quibbles rather than the fact that we presented 15 major successes in fossil energy, nuclear energy, energy efficiency and renewable energy. And, as anyone can see, we have paid for everything we've invested with just a few technologies.

So, I think that's the point that we would like.

Chairman ROHRABACHER. Okay. Well, thank you, Joe. And, we have another member who just arrived.

Mr. Davis, do you have any questions that you would like to ask?

Mr. DAVIS. No.

Chairman ROHRABACHER. Mr. Davis says no. Mr. Roemer, do you have a brief summary?

Mr. ROEMER. Yes. In 30 seconds, Mr. Chairman, I would just say that I am delighted to hear the success stories from the Department of Energy. And, they truly are success stories that have saved the taxpayer billions of dollars.

And, even the GAO report has said that they did not have problems or find a dot in the matrix system with a host of these programs that accumulate about $9.8 billion in savings. And, we would hope that the GAO would continue its past tradition of exemplary work and work that we Members of Congress in a bipartisan way take almost as gospel to use legislatively, to communicate to our district and our constituents; and that, Mr. Li, you would continue to work with this Committee and with the GAO in the future and follow up hopefully on Mr. Brown's letter.

And, Mr. Nemtzow, I would just like to say that your Alliance to Save Energy, your bipartisan efforts, your inclusion of the private sector, much of this success is due to the private sector. And, we want to continue to work with you in those endeavors as well.

Thank you again for your excellent testimony today, all of the panelists.

Chairman ROHRABACHER. And, finally, let me compliment Mr. Li. Mr. Li, you have been put under fire today and you did very well for yourself considering how many people were shooting at you.

And, I will just say that from my perspective, I think a lot of the points that you made were right on target. And, I'm only one Congressman. I'm not speaking as the Chairman of the Committee but I am just speaking as a Congressman.

I think that some of your points were valid. And, I think you handled yourself—under serious attack and having to defend yourself from all directions, you handled yourself exceptionally well.

And, that doesn't mean that some of the points made against what you were doing weren't well made. And, Joe made an overall point that maybe compared your approach to some of the approaches that were taken to the questions that were aimed at you today. So, there is some wisdom to be gained from that.

Let me just say about some of the questions raised about the Chairman's request of information from the Department of Energy, when there was a Republican administration, the number of questions that were aimed at the Department of Energy and other departments from Committees like this were on a similar level as the number of questions that this Chairman has leveled at the Department of Energy and especially the fact that during Republican administrations we did not—I don't believe that the budget was submitted as late—the budget requests were submitted as late as this particular Administration's budget request was submitted. And, it is not in any way harassment that I can see to ever ask any question about something that is in the budget.

If there is a budget request and it is a line in that budget request, it is not harassment for this Chairman to ask a question about it. And, I think it's totally legitimate to do so.

And, because we were under the gun, we had a few more questions this year than we normally would. Or, at least, I did.

One last point, and that is that I'm old enough also to remember the 1970s and what happened and also the 1980s. And, in the 1980s, we eliminated many projects like the ethanol plants which were losing tens of millions, if not billions, of dollars.

We eliminated the shale oil program, which was losing billions and billions and billions of dollars. And, perhaps if we would have kept subsidizing that because of somebody's idea about some future energy crisis, perhaps it would be more clear to everybody that it's not good for the government to get involved and make those decisions that way.

But, it's a difference in philosophy. People have differences in interpretations. And, we can do with courtesy and honesty.

So, thank you very much. I appreciate this Committee today being as aggressive as we were, but also I appreciate the panelists taking the questions in the spirit that they were intended.

So, thank you very much. And, our next panel can move forward.

PANEL 2—FOSSIL ENERGY R&D AND CLEAN COAL TECHNOLOGY

Chairman ROHRABACHER. Our second panel will cover programs of the Office of Fossil Energy. Patricia Godley serves as Assistant Secretary for Fossil Energy at the Department of Energy.

And, Ralph De Gennaro, Executive Director, Taxpayers for Common $ense; and, John Rackley, Vice President of McDermott/Babcock and Wilcox, a firm located in the Research Center in Alliance, Ohio.

Now, there is one other witness, Mr. Tees. Mr. Tees is with the Houston Power and Lighting.

So, we will just proceed, first of all, with Ms. Godley.

STATEMENT OF HON. PATRICIA FRY GODLEY, ASSISTANT SECRETARY FOR FOSSIL ENERGY, UNITED STATES DEPARTMENT OF ENERGY

Ms. GODLEY. Thank you, Mr. Chairman. The budget that the Office of Fossil Energy is presenting to you today does satisfy the commitment that we made to the President and to this Congress to take our share of the pain of reducing the federal budget. And, at the same time, it meets the national goals of allowing this country to continue using its true energy strength.

On the easel at the end of the table down to your right, we've enlarged the chart that's also on the first page of my written testimony that we've submitted for the record. It sends three powerful messages.

First, fossil fuels dominate today's energy portfolio. Eighty-five percent of our energy consumption today comes from coal, oil and natural gas. Our economy, quite simply, would not be the strongest in the world today if it wasn't for these fuels.

Second, energy demand in this country is going to continue to grow. Our best forecasts are that energy consumption will increase by 19 percent over the next two decades. By the year 2015, the pie on the top right of this chart will be 19 percent larger than its counterpart on the left.

Third, and perhaps most important, Mr. Chairman, the contribution of fossil fuels to our energy mix won't decline over this time period. The role of these fuels in our economy will actually grow. By the year 2015, 88 percent of our energy will come from fossil fuels, 88 percent.

So, Mr. Chairman, the task in front of our nation today and this government and the citizens of this country, as it looks to the future, is to determine how we are going to accommodate the growing contribution of fossil fuels while at the same time protecting the environment and minimizing the security threat that would come from increasing reliance on imported fuel resources that may be beyond our control; and, third, to ensure an even playing field for U.S. companies competing in the global energy marketplace. These three things are appropriate federal roles to invest in these public interest objectives where industry cannot do it alone.

And, my testimony goes into more detail about the situation with our energy industries, but I will just point out that the nation is undergoing an unprecedented restructuring in the energy segments. And, we are finding that the private sector is investing 30 percent less dollars, less investment, in R&D than it has been in the recent past.

Membership in the Electric Power Research Institute is dropping. Private sector R&D investments across the board are declining in the electric power industry.

Anything that doesn't have a direct and positive impact on the company's bottom line in a six month time frame per year or a year is being dropped. This same trend is occurring in the gas industry.

You've read recently in the past that the Gas Research Institute, the research arm of the gas industry, has cut back its research program by 20 percent, stating that its funding base has continued to erode because of increasing competitive pressures brought about by deregulation in the gas industry.

In the oil industry, the migration of large oil companies overseas to more lucrative prospects and larger opportunities to increase the diversity of oil supply in the world continues. Meanwhile, U.S. wells continue to shut down prematurely, in some cases, because technology isn't available or isn't available at an affordable cost to keep them producing.

Thirty percent drop in industry investment in these important sectors, R&D.

Meanwhile, as we've talked about before, the global market opportunities for advanced fossil fuel technologies are greater than ever before. The world is going to require huge new supplies of energy.

And, there is no dispute that those new supplies are going to come from fossil energy resources across the world. Our global competitors know exactly what these market opportunities are.

And, they also know the advantages that those foreign governments can give their industries by creating government industry partnerships modeled, ironically enough, after the industry partnerships that this government has forged in the United States. Japan now spends as much as this country does, dollar for dollar, on advanced coal combustion technology research, because it knows that better coal burning equipment will be what sells in the world marketplace in the coming years.

The Japanese reportedly spend three times more than we do on fuel cells research, because they know if that R&D turns out to be successful they will have a product that will sell in the global marketplace in the 21st century. That's why they are subsidizing straight out also their advanced gas turbine industry.

Japan, Germany and other nations in Europe are looking towards these new huge markets and putting best efforts behind capturing their share of those markets and ours.

Also, our programs though, the programs that we are developing in the Office of Fossil Energy, increase the protection of the environment as we increase the use of fossil fuels without driving up energy costs. Take for just one example carbon dioxide emissions.

More than 92 percent of total global manmade carbon emissions are released outside of the United States. It's important to deploy these cleaner, coal-burning, more efficient coal-burning technologies and fossil energy power technologies outside of the United States as well.

Mr. Chairman, the budget that we are presenting to you today meets the bipartisan goals of reducing federal spending. There are 12 major categories of funding in our R&D program.

We are proposing less money in 11 of those 12 categories. The twelfth one, by the way, is environmental remediation of our sites.

We have cut administrative overhead by nearly 22 percent since 1995. We are creating a more streamlined and less costly management structure in our office.

Overall, in our R&D program, our funding level declines 17 percent in Fiscal Year 1997. And, we are privatizing Elk Hills and moving this purely commercial oil field out in the private sector where it belongs.

We are reinventing government in the Office of Fossil Energy.

And, I would like to acknowledge, if I could have 30 more seconds, the compliments mentioned by Congressman Doyle. But, I want to put those in context.

The fossil energy budget is a piece of an overall balanced budget proposal by the Department of Energy and applied scientific R&D in the energy area. It's part of a balanced budget proposal that includes the other offices within the Department.

And, that's why we are recommending this budget. And, we are able to bring down our budget in the context of a balanced budget for investment in these important technologies.

And, I appreciate your courtesy. Thank you.

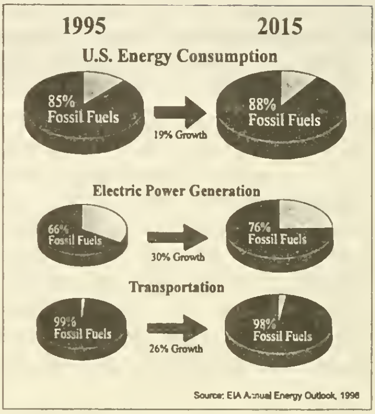
[The prepared statement of Ms. Fry Godley follows:]

Statement of
Patricia Fry Godley
Assistant Secretary for Fossil Energy
U.S. Department of Energy
before the
Subcommittee on Energy and Environment
Committee on Science
U.S. House of Representatives
April 17, 1996

The FY 1997 Fossil Energy Budget
MEETING OUR COMMITMENTS

Our FY 1997 Fossil Energy budget is based on the necessity of fossil fuels to our economy and economies of virtually every country around the globe. Today 85% of our domestic energy consumption is supplied by fossil fuels; by 2015, the contribution of fossil fuels will grow to 88%. Every credible energy expert believes that the foreseeable national and global energy future, like the present, will be shaped predominantly by fossil energy.

Our vision is that the benefits of fossil energy use – affordable prices, a stronger economy, greater employment, and a contribution toward improved global prosperity – can be realized at the same time we dramatically improve our environment. Moreover, we believe that the Federal Government has a major role – indeed a responsibility – in making that vision a reality.



Source: EIA Annual Energy Outlook, 1996

As energy consumption grows, fossil fuels will remain the Nation's energy mainstays.

At the same time, we remain cognizant of our commitments to fiscal stewardship. Our FY 1997 budget contains sharp reductions in the Clean Coal Technology Program, which we believe can be achieved without compromising our cost-sharing obligations to our private sector partners. It also includes reductions in our Research and Development Program, reflecting the completion of some programs, fewer research contractors in others, and overall management savings achieved by restructuring the Office of Fossil Energy organization.

In programs outside of this Committee's direct jurisdiction, our FY 1997 budget maintains a minimum level of activity at the Naval Petroleum and Oil Shale Reserves while privatization initiatives are underway, and requests budget authority over the FY 1996 budget only in the Strategic Petroleum Reserve program, where past balances from other accounts are no longer available to offset funding requirements.

OUR COMMITMENT TO RESULTS

The U.S. Federal investment in Fossil Energy R&D was over $400 million last year, it will be about $380 million this year, and the proposal for FY 1997 is about $348 million. Another $200 million to $250 million is spent annually on maintaining the Strategic Petroleum Reserve. For that kind of money, the taxpayer has a right to expect results. Our program will deliver them.

- In the 2000-2010 timeframe, advanced technologies emerging from our program will permit U.S. industry to reduce emissions of nitrogen oxides and air toxics from existing power plants by 70-90% and reduce the cost of meeting existing and future regulations by over $7 billion per year.

- Advanced power systems, dominated initially by natural gas technologies and later including new generations of coal systems, will not only be cleaner and more efficient than current systems, they will produce lower-cost electricity. This combination of improved environmental performance and greater affordability will be critical if U.S. companies are to compete – and win – in the domestic market and a burgeoning global market. Opportunities for increased sales of U.S.-technology could amount to $6-10 billion a year from 2001 to 2030. If we do not capture these market opportunities, foreign competitors and foreign technologies will.

- The combination of reduced environmental compliance costs and the lower costs of new electric power supplies can have a dramatic impact on a domestic economy that already spends $200 billion a year for electricity. Lower cost innovations in the power industry will certainly evolve more slowly and, particularly in the case of environmental compliance equipment, may not evolve at all without Federal R&D. Yet by using technologies from our program, U.S. industry could reduce annual electricity costs by $8-13 billion beginning in the 2001-2010 timeframe.

- By assisting the domestic industry develop more effective and lower cost technologies to find and recover U.S. oil and natural gas, we can reduce the decline in domestic oil production by 1 million barrels per day and increase U.S. natural gas production by 2 trillion cubic feet per year beginning in the 2010-2015 timeframe. This increased U.S. production will directly benefit our economy by generating more than $11 billion a year in domestic oil and gas sales – dollars that will stay in this country rather than flowing to foreign suppliers.

- Technologies emerging from the Federal R&D program provide U.S. policy makers with a more affordable alternative to future "command-and-control" environmental regulations. Particularly in regard to emissions of greeenhouse gases and air toxics, our programs could potentially save the U.S. economy billions of dollars in costly new regulations.

While ambitious, our goals are achieveable because they build on a solid technological foundation – a foundation that exists because the U.S. has invested in clean, secure fossil energy technologies. For example, because of prior support for Federal fossil fuel research:

- In the early 1980s, our best studies showed that the most we could hope to achieve in terms of **coal-to-electricity efficiencies** was 38% – a small increase over the power industry's average of about 33-34%. Today, technologies demonstrated in our program are already operating at efficiencies of 42-43%. Our goal now is to push for efficiencies of 50-60% while lowering electricity costs. An important added benefit is that such systems emit much less CO_2 for each watt of electricity generated.

- In the early 1980s, oil and gas producers were stymied by continual failures of **diamond cutting drill bits**. DOE R&D solved the durability problem, and today, longer-lasting polycrystalline diamond drill bits save as much as $1 million per well. Our goal now is to build industry's confidence in a new array of 21st century drilling and production technologies, such as air drilling and carbon dioxide-sand fracturing. Reducing drilling costs makes it practical to produce more oil and gas from U.S. reserves.

- When the Clean Air Act Amendments were passed in 1990, industry faced the prospects of huge costs for **controlling nitrogen oxides** (NOx). Today, because of successful demonstrations in the Clean Coal Technology Program, NOx reduction technologies perform far better than previous technologies, yet are among the lowest cost options available. One fourth of the coal-fired capacity in the U.S. now employs these technologies.

- Because of our investment in clean coal technologies, we have inaugurated a new era of **clean electric power generation from coal.** The pioneering Wabash River Coal Gasification Plant in Indiana, dedicated on November 8, 1995, is heralding an entirely new way to generate electricity from coal with sharply reduced environmental emissions and increased efficiency. In FY 1997, the Tampa (FL) and Sierra Pacific (NV) projects will add to U.S. leadership in gasification-based power technology.

- 10 DOE cost-shared oil recovery projects now have made available at least 40 million barrels of **additional crude oil** that otherwise would have been left in the ground. Moreover, these projects have encouraged additional privately-sponsored field operations, producing millions of barrels of additional oil from U.S. fields and hundreds of millions of dollars in additional royalty revenue and other economic benefits.

- A DOE-cosponsored **horizontal test well** in Michigan is producing 100 barrels of crude oil per day — easily surpassing the 5-barrel per day output of the best conventional well in the field. It could rejuvenate an oil-producing region that was on the verge of being abandoned.

- A new array of **"high-tech" oil and gas exploration tools** that can probe for hydrocarbons faster, deeper and with unprecedented accuracy is now being made available to industry.

Ranging from 4-dimensional seismic analysis (where time is incorporated into the equations) to rugged seismic sources that can be lowered deep into boreholes, to a novel device that can detect hydrocarbons through the metal casing of older wells, these new technologies offer the prospects of discovering oil and natural gas deposits that have been missed by conventional methods.

- A sophisticated methodology that allows State regulators to validate **"area of review" variance requests** for oil and gas disposal and injection wells has saved East Texas producers more than $86 million in regulatory compliance costs.

- "Booked" natural gas reserves in Southwest Texas are being increased by nearly 4 trillion cubic feet due to DOE's support of a **"secondary gas recovery"** project that discovered large quantities of natural gas bypassed by standard field operations. Gross production revenues from these reserve additions alone could approach $1.4 billion.

- The first **"advanced generation" fuel cells** are on schedule to begin testing in commercial settings this spring and summer. Intended to feed critical operational data back into the R&D program to lower costs, these field units (in Santa Clara and San Diego, CA) will help keep the U.S. perhaps 2 to 3 years ahead of foreign technology competitors.

OUR COMMITMENT TO FISCAL STEWARDSHIP

The American taxpayer also has the right to expect the Federal Government to spend dollars prudently. The Congress has been blunt and direct in demanding federal agencies provide more benefits and products for lower budgets. We hear you.

Last year our budget for fossil energy research and development was $417 million. This year's funding will be about $377 million (on a comparable basis, i.e., without counting mining R&D transfers and prior year offsets). For FY 1997, we are requesting $343 million, over 20% less than budgeted in FY 1995 (plus an additional $5 million for materials R&D transferred from the Bureau of Mines).

Our budget is smaller, but we are not abandoning our responsibility to help solve critical national energy problems. Our strategy for addressing these issues with reduced resources consists of four components:

1. Sharply defining the *appropriate role for the Federal Government* and eliminating all non-essential or inappropriate research.

2. *Leveraging taxpayer funds* to the greatest extent possible, forming public/private partnerships where the national objective is common with private sector objectives.

3. Investing in *cutting edge technology* where the potential exists to "leap frog" traditional evolutionary advances that are more appropriate for private sector investment.

4. Implementing *better Federal management practices.*

The Federal Role

Within our R&D program, we have resisted the impulse to merely defend the status quo. The FY 1997 budget does not contain projects where there is no longer strong justification for Federal involvement. We have given highest priority to projects whose payoffs don't occur until the next decade and beyond, much farther into the future than the timeframe of current private sector R&D.

The Federal Government has a unique role in assuring that regulatory requirements, for example in the area of environmental compliance, do not choke our economy. As the originator of many of these regulatory requirements, the Federal Government can, and should, assist industry in developing technologies that can meet the standards cost-effectively. The track record in this area is good.

At many new power plants, the cost of complying with sulfur dioxide (SO_2) regulations is now about half what it was a decade or so ago largely because of Government-industry R&D partnerships. Most new nitrogen oxide control (NOx) technologies now being installed on existing power plants are products of joint Federal/private efforts. Today because of DOE's R&D, we know much more about the nature and amount of potentially toxic air pollutants that are released from power plants, so that any future regulations, if necessary, can be based on sound science. We have developed environmental management systems that dramatically reduce the cost of preventing ground water pollution from oil and gas wells, and we are now working with State regulators to implement these better approaches to regulation.

The Federal Government also has a unique role in preparing this country for future environmental challenges. Today, for example, there is no strong economic incentive for the private sector to conduct research on reducing greenhouse gas emissions. Yet, one day such reductions may become an environmental imperative.

The world is using more fossil fuels, especially coal. In fact, more than 92% of total global manmade carbon emissions are released from outside the United States. Finding an affordable, technological way to cut greenhouse gas emissions may not only preclude the need for costly "command-and-control" regulations, it can create exportable technologies that sharply reduce the *global* growth in greenhouse gas emissions. The higher-efficiency technologies in our FY 1997 R&D program offer these technological alternatives; they lower CO_2 emissions by more than 40% compared to existing options while, at the same time, *reducing* energy costs.

The Federal Government also has a unique role in assuring the security of the United States. Increasingly, economic security – and perhaps eventually, even national security – is inextricably tied to energy security. The role of our Strategic Petroleum Reserve as both a deterrent and a defense to future oil embargoes is obvious. The Reserve, however, is a short-term response. Over the longer-term, our security may be increasingly linked to how well we can produce secure sources of fuels domestically. Indeed, the Energy Information Administration's current energy projections show an upturn in domestic oil production – but only if new technologies become available.

Likewise, advanced technology may one day allow us to use the *full range* of our domestic resources to produce critically needed liquid fuels. For example, while the payoffs of converting coal and natural gas to liquid fuels are too distant to encourage much private sector R&D, Federal R&D has made important advances that have likely shortened the timeframe for these options. It may be possible with advanced technology now at the laboratory and benchscale to produce liquid fuels from coal at the equivalent of $25 per barrel of oil by 2010. The Energy Information Administration projects that the price of oil should pass $25 per barrel in the year 2015. Therefore, if our long-range R&D is successful, we can provide policy makers with a new, domestically-secure option to ensure adequate energy to fuel our economy.

Leveraging Government Funds

The Clean Coal Technology Program and our Oil Recovery Field Demonstration Program are perhaps the best examples of government/private sector teaming and cost-sharing. In both, private sector funding accounts for about 60%. We have extended this cost-sharing principle to other Fossil Energy research activities, particularly for those R&D efforts that are beginning to show commercial promise.

For example, as our advanced fuel cell and gas turbine research continues to progress into more mature stages of engineering development, the Federal funding share has declined and the private sector contribution has increased markedly. In these programs, by the time the final stage of R&D is reached, private cost-sharing will be 60-70% of the development costs. The same increases in private sector cost-sharing can also be found in several other parts of our R&D program.

As the private sector sharply cuts back its R&D investments, we have found that Federal cost-sharing is being viewed by industrial developers as increasingly important in preserving technological progress. In turn, we use cost-sharing as a clear gauge on whether the R&D we are pursuing continues to attract private sector support.

Investing in "Leap Frog" Technology

Our world is rapidly changing, and the rate of change is accelerating as technology advances. Emerging innovations in data and information technology (like computers and advanced communications), advanced materials (ceramics and composites), miniaturization, catalysts, and biotechnology can have dramatic effects on the future of energy technology.

Beginning in FY 1997, we will be carrying out a small effort to ensure that we are taking full advantage of research progress in areas that may not have been viewed in the past as traditional fossil fuel disciplines. We will ensure that researchers outside of our program are familiar with energy research needs which might benefit from these emerging technologies.

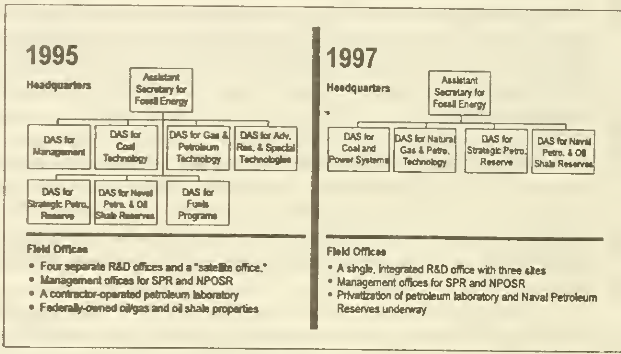
For example, we envision a future in which the cost of expensive demonstration plants can be dramatically mitigated by demonstrating small scale components and simulating the effect of scale-up and integration with advanced computer programs. There is also the long-range potential of applying genetic engineering and biological processes to solving difficult environmental problems at much lower costs than traditional chemical approaches.

In other words, we are positioning our program for the post-2000 era in which creativity and imagination can lead to significant cost- and time-savings in developing new energy products.

Managing Government Funds Better

Both Congress and the Administration agree on the need to improve management efficiency throughout Government, permitting more funding to go to vital programs and less to administrative overhead.

Our FY 1997 budget reflects the first year of the substantial savings that were envisioned when the Department initiated its Strategic Alignment Initiative in 1994. Management costs in the FY 1997 research and development program will be nearly 22% less than in FY 1995. We will save at least $125 million over the next five years by streamlining our headquarters organization and by consolidating management and administrative functions at our three R&D field centers. By the end of FY 1996, instead of three separate field offices each with their own administrative staff, we will have a single, integrated field office sharing administrative resources at three locations.


1995
Headquarters
Assistant Secretary for Fossil Energy
DAS for Management
DAS for Coal Technology
DAS for Gas & Petroleum Technology
DAS for Adv. Res. & Special Technologies
DAS for Strategic Petro. Reserve
DAS for Naval Petro. & Oil Shale Reserves
DAS for Fuels Programs
Field Offices
• Four separate R&D offices and a "satellite office."
• Management offices for SPR and NPOSR
• A contractor-operated petroleum laboratory
• Federally-owned oil/gas and oil shale properties
1997
Headquarters
Assistant Secretary for Fossil Energy
DAS for Coal and Power Systems
DAS for Natural Gas & Petro. Technology
DAS for Strategic Petro. Reserve
DAS for Naval Petro. & Oil Shale Reserves
Field Offices
• A single, integrated R&D office with three sites
• Management offices for SPR and NPOSR
• Privatization of petroleum laboratory and Naval Petroleum Reserves underway

Our 1997 headquarters organization will have three fewer Deputy Assistant Secretaries and a significantly restructured field organization.

We have already eliminated two smaller field research offices (at Metairie, LA, and Laramie, WY). By the end of FY 1996, we will have three fewer Deputy Assistant Secretary offices at headquarters than we had in 1995. By the end of FY 1997, our Federal research and development staff (at both headquarters and in the consolidated field offices) will be over 150 positions less than in FY 1995, while our contractor workforce will be reduced by more than 300 positions. Our plans to privatize the National Institute for Petroleum and Energy Research in Bartlesville, OK, beginning this summer, are projected to save the Government $25-35 million.

THE FY 1997 FOSSIL ENERGY R&D PROGRAM

Our proposal for Fossil Energy R&D funding in FY 1997 is predicated on:

- Ensuring that all projects reflect a correct perspective on the appropriate role of the Federal Government in energy R&D;
- Providing American taxpayers with real measureable results in terms of energy, environmental and economic benefits;
- Minimizing the cost of research through careful planning and effective management.

The result is the following budget proposal:

FOSSIL ENERGY R&D (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	FY 1997 Request	Change from FY96
Coal Technology R&D	$130.18	$108.88	$91.97	-15%
Natural Gas R&D	109.47	112.19	103.71	-8%
Petroleum R&D	75.21	55.71	52.54	-6%
Advanced Crosscutting Research	14.28	12.38	10.66	-14%
Program Direction & Management	72.66	66.60	57.16	-14%
Plant & Capital Equipment	5.01	4.00	3.30	-18%
Environmental Restoration	15.30	14.92	15.03	+1%
Cooperative R&D	8.86	6.30	4.00	-36%
Fuels Programs (Regulatory)	3.00	2.69	2.19	-19%
Mining R&D (transfer from DOI)	0	40.00	5.00	NA (transfer)
DOE-Wide Working Capital Fund	4.27*	4.33*	2.95	-32%
Subtotal	$438.24	$428.00	$348.51	-19%
Prior Year Offsets	-16.87	-6.50	0	
Total - Fossil Energy R&D	$421.37	$421.50	$348.51	-17%

*Shown for comparability purposes

To improve our management and take advantage of program synergies, we have begun incorporating a "business line" approach. Rather than managing the Fossil Energy research program, solely by fuel types (coal, oil, natural gas), we approach our strategic planning and implementation from the perspective of market sectors, e.g., electric power systems, natural gas and oil exploration and production, advanced clean fuels production, etc. This testimony is organized in this manner:

Advanced Electric Power Systems R&D - Keeping Innovation Alive as the U.S. Market Restructures

Our FY 1997 research program on advanced generations of high-efficiency power systems is funded from both the coal and natural gas budgets. The major elements are:

ADVANCED POWER SYSTEMS (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	**FY 1997 Request**	Change from FY96
Coal - Advanced Clean/Efficient Power Systems	$87.66	$80.28	**$66.81**	-17%
Natural Gas - Advanced Turbines	$36.98	$36.77	**$31.60**	-14%
Natural Gas - Fuel Cells	$46.96	$52.46	**$46.62**	-11%
Total - Advanced Power Systems	**$172.60**	**$169.51**	**$145.03**	-14%

This budget request has been shaped by two major challenges that confront the U.S.:

1. The risk that the United States will lose a substantial share of the global power technology market if it does not sustain the same type of government/industry R&D partnerships that our competitors are now creating;

2. The profound changes in the U.S. utility sector's approach to R&D which have sharply curtailed private funding and shifted the remaining dollars primarily to projects with almost immediate payoffs. A principle "victim" of private sector cutbacks has been long-term R&D for "public good" benefits such as lower cost environmental protection, even though there is strong public expectation that environmental quality must continue to improve even as our economy grows and energy consumption rises.

The Global Economic Challenge - Nowhere is global competition more intense than in the worldwide electric power market.

The world is increasingly turning to electricity to power economic growth. Outside the United States, the market for electric power systems could be as large as $1 trillion in 2015. A country that captures only 20% of this market would sell more than 400,000 megawatts of power generating capacity and bring in revenues of nearly $200 billion.

We can be such a country if we agressively pursue technology development in joint government-industry partnerships.

Other governments certainly recognize the potential. The governments of Japan and Germany, for example, have increased cooperative efforts with their private companies to develop technologies for global sale. Japan, in spite of a flat economy, has nearly tripled its funding over the past five years for advanced coal combustion technology – the technology most in demand in the world export market. Today, on a dollar-for-dollar basis, the Japanese government's investment in cleaner, more efficient coal-burning technology matches that of the United States. Japan reportedly spends nearly three times more on fuel cell research.

The Decline in U.S. Private Sector R&D - While other countries increase their energy R&D investments, public and private expenditures for energy R&D in the United States continue to decline.

In the U.S., the utility sector is struggling with the uncertainties of approaching widescale deregulation. While some States that are leading the restructuring are adopting policies to promote some categories of R&D, during this critical transition period Federal R&D support becomes even more important in sustaining the Nation's technological progress. Confronted by uncertainty, power companies have sharpened their focus to more immediate concerns, seeking a competitive edge primarily by cutting costs. R&D funding, especially for the longer term, has been severely reduced. Utility heavyweights, including all of the Florida utilities, have withdrawn from the Electric Power Research Institute (EPRI) as a result of competitive pressures to cut costs.

In the January/February 1996 issue of *EPRI Journal*, EPRI's Vice President Kurt Yeager writes "...as competition intensifies, strategic planning horizons are shrinking. For many utilities, it's a question of how an investment will pay off not three or five years down the road but over the next six months or year ...." [Emphasis added].

The private sector's focus on near-term competitive needs means that the Federal government is playing an increasingly important role in maintaining the Nation's R&D progress toward energy systems for the post-2000 timeframe. In today's R&D climate, beyond the year 2000 is "long term," and that is where our R&D program is targeted.

The FY 1997 Federal Program - Our request for advanced power systems R&D is $66.8 million in the Coal R&D budget and $78.2 million in the Natural Gas R&D budget. In both programs, our focus is on developing the technical foundation for concepts in the 2000-2010 timeframe for commercial readiness – well beyond the R&D horizon of today's private sector.

The **coal-related power systems funding** will support longer-range technologies with a goal of reducing emission levels to 1/10th of today's permissible limits, boosting efficiencies to levels beyond 50% (today's plants operate at 33-34% efficiency levels), and reducing CO_2 emissions by 40% or more — while at the same time, reducing the costs of generating electricity by 10-20%. Our request includes $57.0 million in funding for advanced low emission boiler concepts, new generations of pressurized fluidized bed combustion and integrated gasification combined cycle systems, and the innovative concept of an indirectly fired, combined cycle system. Another $9.8 million is requested for research on advanced environmental control systems that can reduce air toxics, fine particulates and other air emissions, as well as longer-term research on CO_2 control and disposal.

The **natural gas power systems funding** involves research on advanced gas turbines and fuel cells. In both, our target is to develop the first prototypes of market-ready advanced systems in time (by the year 2000) to meet the "window" for technology exports to underpowered regions of the world. Our advanced turbine program ($31.6 million) remains on pace to develop by the year 2000 an ultra-high efficiency (exceeding 60%) turbine that can give the U.S. a virtually insurmountable technical lead in the global market. Our fuel cell program in FY 1997 ($46.6 million) will continue the R&D push necessary to position U.S. industry to introduce advanced molten carbonate and solid oxide fuel cells into the multi-kilowatt onsite and low megawatt utility markets in the year 2000. Ultimately, in the post-2000 timeframe, our research program will result in both fuel cells and advanced turbines being adapted for coal as well as natural gas.

Advanced Clean Fuels Research - Providing a Long-Term Alternative to Imported Oil

Our request for $15.95 million for advanced coal-based clean fuels research keeps the option available to one day refine coal to a variety of liquid fuels and chemicals that might be needed as substitutes for petroleum-based products. This reduced funding will continue to keep our program progressing toward the goal of producing clean liquids from coal at a cost of $25 per barrel. Progress to date has developed liquefaction technology that has reduced the cost of producing clean coal liquids from $50 per barrel in 1980 to a projected commercial cost of about $32 per barrel today. In FY 1997, the liquefaction program will focus on advanced catalysts and innovative coal-waste and other co-processing concepts that are critical next steps in meeting our cost goals.

The coal preparation budget will continue to emphasize advanced methods for removing the impurities that can cause emissions of air toxics and other air pollutants. Advanced coal cleaning has the potential to provide the lowest cost means of reducing mercury emissions from power plants.

The funding levels for this program are:

ADV. CLEAN FUELS RESEARCH (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	FY 1997 Request	Change from FY96
Coal Preparation	$7.04	$4.66	$5.10	+9%
Direct Liquefaction	8.62	5.58	5.86	+5%
Indirect Liquefaction	12.20	5.84	4.25	-27%
Adv. Research & Environmental Tech.	3.90	3.55	0.75	-79%
Systems for Coproducts	0.90	0	0	
Total, Advanced Clean Fuels Research	$31.85	$19.63	$15.95	-19%

Advanced Research and Technology Development - Undergirding Tomorrow's Advances

This research provides the fundamental science and engineering basis for future fossil fuel concepts. In the FY 1997 budget we have organized this activity into two categories: (1) Coal-specific research and analysis, and (2) Fossil Energy-wide support. This reflects that some activities previously shown under the coal R&D budget actually benefit the natural gas and petroleum R&D programs as well. The funding levels for this program are:

ADV. RES. & TECH. DEVELOPMENT (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	FY 1997 Request	Change from FY96
Coal-Specific Research & Analysis				
- Coal Utilization Science	$3.04	$3.15	$3.15	--
- Coal Technology Export	0.82	0.82	1.05	+28%
- Bioprocessing of Coal	1.93	1.00	1.00	-
- University Coal Research	4.90	4.00	4.00	-
Fossil Energy-Wide Support				
- Materials and Components	8.57	6.93	5.27	-24%
- Environmental Activities	1.81	2.51	2.24	-11%
- Technical and Economic Analysis	0.69	0.96	0.86	-10%
- International Program Support	1.30	1.01	1.16	+15%
- Instrumentation and Diagnostics	0.96	0	0	-
- HBCU, Education and Training	0.94	0.97	1.14	+17%
Total, Adv. Research & Tech. Development	$24.96	$21.35	$19.87	-7%

Natural Gas and Petroleum Exploration & Production - Tapping the Full Potential of Secure Domestic Supplies

Today the United States is not able to tap the full potential of its domestic petroleum and natural gas resources. Continuing low world oil prices have imposed a severe disincentive on the private sector's development of advanced exploration and production technologies.

Even though we are endowed with huge quantities of unproduced petroleum, the profit margin to produce oil from much of our domestic resource base is extremely thin or, in some cases, virtually non-existent in today's economic environment. Thus, increasing amounts of oil are imported into the U.S. while domestic oil resources remain unproduced.

Likewise, trillions of cubic feet of natural gas remain locked in deposits that are too difficult or expensive to extract with today's technology. Lower cost, more effective technology could bring this gas onto the market, helping to further diversity our domestic energy mix. But low gas prices are discouraging private investment in the needed R&D.

The FY 1997 Fossil Energy budget is attempting to address this situation by developing technologies that lower the cost of finding and producing crude oil and natural gas in the United States. Our budget request includes:

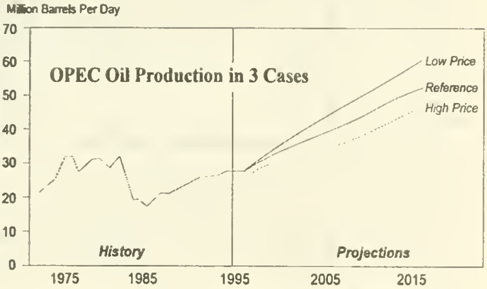
NATURAL GAS and PETROLEUM EXPLORATION & PRODUCTION (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	**FY 1997 Request**	Change from FY96
Natural Gas				
- Exploration & Production	$18.37	$14.16	**$15.00**	+6%
Petroleum				
- Recovery Field Demonstrations	28.29	11.08	**6.10**	-45%
- Exploration & Production Supporting Research	35.43	33.48	**34.02**	+2%
Total, Exploration & Production	$82.09	$58.72	**$55.12**	-6%

The Threat of Increasing Oil Imports - Low cost foreign oil continues to flow into the United States at all-time record rates. Immediately prior to the 1973 oil crisis, the U.S. was importing less than 27% of its crude oil. When the 1979 oil price shock hit, U.S. imports were less than 43% of the Nation's oil consumption. Today, oil imports account for 46% of our oil needs, and by 2010, could account for more than 60% of our supply.

In fact, just the increase in U.S. crude oil imports in the last 10 years (1985 to the present) – from 5.1 million barrels per day to nearly 9 million barrels per day – is itself greater than the total oil consumption of any other country in the world, except Japan and Russia.

Although non-OPEC nations did increase production by almost 15 percent from 1980 to 1990, they increased proven reserves by only 10 percent. On the other hand, while OPEC increased production by 20 percent in the 1980s, it increased its proven reserves by 75 percent. As a result, OPEC's reserves-to-production ratio doubled to 90 years while the remaining years of production for non-OPEC reserves have actually fallen, from 18 years to 17 years.

This situation raises the likelihood that the potentially unstable Persian Gulf could return to dominance in meeting the world's growing appetite for oil. With two-thirds of the world's oil reserves, the Persian Gulf is expected to supply more than 75% of the increase in global demand for oil over the next 15 years. By 2010, the Persian Gulf's share of the world export market could surpass its highest level to date - 67% - attained in 1974. If low oil prices persist, fully 75% of the world's petroleum trade could be supplied by the Persian Gulf by the end of the next decade.



EIA Annual Energy Outlook 1996

OPEC, with its vast store of readily accessible oil reserves, is likely to be the major supplier of the world's increasing demand for oil. EIA forecasts that by 2010, OPEC could be producing about twice the level it produced in 1990.

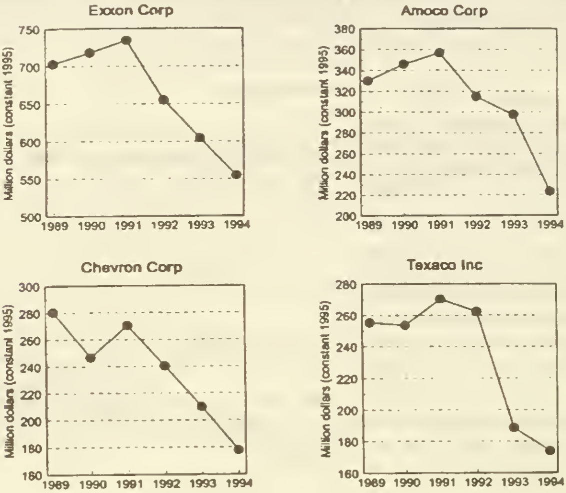
Decline in U.S. Oil Production Hastened by High Production Costs and Lack of Private Investment - Even as foreign oil imports rise, the U.S. continues to abandon domestic wells at an alarming rate. In the last 10 years, more than 173,000 U.S. oil wells have been abandoned. Oil production from stripper wells is now at its lowest level in nearly 50 years.

With low oil prices expected to persist, the marginal U.S. producer (now almost solely a small, independent company working on the economic edge) increasingly faces the likelihood of plugging and walking away from uneconomic wells, despite the fact that billions of barrels of producible oil still remain in the ground. By 2020, as much as 80% of the U.S.'s remaining oil resource could be abandoned unless better technologies become available.

Historically, independent producers (who drill 85% of U.S. wells) could look to the major oil companies for new technologies that could improve the prospects for keeping U.S. oil fields active. But that is no longer the case.

The following charts shows R&D spending by four major oil producers. Although these charts include several categories of company-sponsored R&D – and it is difficult to separate funding for upstream and downstream oil R&D and other corporate R&D activities – the trends are unmistakeable:

Research Spending by Major Oil Companies



Source: Schonfeld and Associates 1995, 1994

In the natural gas industry, the 337-member Gas Research Institute (GRI) recently announced a 20% reduction in its 1996 research program, stating that its "funding base has continued to erode" because of increasing competitive pressures brought about by deregulation. The institute proposes to eliminate 1996 funding for 17 previously-approved projects. It has already announced staff cuts and predicts that more personnel and research cuts will occur in 1997.

Private sector oil and gas technology developers – like the industry itself – are in a state of transition brought on by the collapse of oil prices in the 1980s and the expectation of constrained oil and gas prices in the foreseeable future. While opinions differed on the impact of reductions in private sector R&D spending in a recent National Petroleum Council survey, the Council's consensus was that "besides the direct pressures on in-house developers created by oil prices and resulting requirements for cost reduction, there are other indirect pressures that have resulted in a greater proportion of *short-term and technical service-type activities*." [Emphasis added]

The Potential for Natural Gas - Research cutbacks are coming at a time when natural gas use is projected to grow significantly in the U.S. energy market. Traditionally its most important use has been in the residential sector (where it supplies nearly half of all energy consumption), but in the future, natural gas is projected to increase its contribution in other energy sectors, most notably in the electric power generation and transportation markets. In fact, the Energy Information Administration forecasts that domestic natural gas consumption will increase by one-third over the next 20 years. About half of this increase will be to fuel electric power plants.

For the full potential of domestic natural gas to be realized, consumers must be confident that long-term supplies are adequate and affordable. Particularly in the electric utility market, where decisions are based on 30 year-plus plant life expectancies, the long-term future of natural gas reserves must be assured. Technology will largely determine whether or not these assurances can be given.

For example, in February 1995, the U.S. Geological Survey doubled its estimates of the nation's onshore inferred natural gas reserves (from 114 trillion cubic feet in 1995 to 232 trillion cubic feet in 1996). The reason for this increase was largely attributed to the rates of technological progress applied to exploration, drilling, and production. In the future, a significantly greater share of U.S. natural gas production will have to come from frontier supply sources, e.g., dense formations in the West and deeper gas formations both on- and offshore. In these formations, gas production will be much more sensitive to the rate of technology improvement than in the past.

In other words, for U.S. consumers (especially utilities) to have sufficient confidence to make the 30-year or more investments in new gas applications (like turbine and fuel cell-based power plants) that can expand the use of natural gas in the United States, R&D investments must be made today to assure adequate gas supplies in the 2010-2050 timeframe. Privately-sponsored R&D is not focusing on this long-range time horizon.

The FY 1997 Federal Program - Our request for $55.12 million in advanced exploration and production technology ($15.00 million in the natural gas program; $40.12 million in the petroleum program) will continue our highly-leveraged program with U.S. industry to bring down the costs of production through implementation of innovations in exploration, drilling, and production technologies. Through a combination of improved technologies and lower regulatory compliance costs (see p. 18), our goals are to:

- assist domestic producers increase domestic oil production by nearly 1 million barrels per day by 2015 (equivalent to nearly 1 out of 6 barrels produced from U.S. fields in 2015);

- assist natural gas producers increase their production by nearly 2 trillion cubic feet per year (7% of expected demand) by 2010;

- enhance the value of Federal lands which account for 20% of the Nation's oil production and 35% of the Nation's natural gas production.

In the **natural gas exploration and production program**, our research will continue to concentrate on innovative technologies that can dramatically increase the speed and accuracy at which wells can be drilled, reduce damage to underground formations (thereby extending the life of production), and reduce the investment costs of drilling equipment. Given that U.S. industry is projected to spend nearly $14 billion by 2010 to drill new gas wells, even a small improvement in drilling costs can have enormous benefits. Slimhole drilling tools being developed in our partnership program with industry, for example, are projected to reduce drilling costs by 40%. Underbalanced drilling technology and advanced downhole telemetry systems also hold the potential for significantly lowering the costs of drilling new wells.

We will continue to study advanced techniques for producing natural gas from the low-permeability formations of the West (such as the Greater Green River and other priority basins in Wyoming, Utah and Colorado). These hard-to-produce reservoirs are critical to providing long-term confidence in natural gas supplies. Advanced research in fracture detection and mapping that is well beyond the timeframes of today's industry can boost production from these domestic resources for many decades into the 21st century. We have also included funding for our part of joint efforts with the U.S. Geological Survey to develop a better "engineering profile" of the national gas resource base, something that is beyond the scope of individual companies.

In the **oil exploration and production programs**, our focus will be on two major activities: 1) the joint government-industry, recovery field demonstration program; and 2) the longer-range, supporting research program.

In the recovery field demonstration program, in FY 1997 we intend to complete Federal funding for all of the "reservoir class" field projects and carry out a limited effort to assist companies develop better reservoir management techniques in economically-marginal fields and to help small operators find ways to keep marginal wells in production.

Our supporting research program looks well into the 21st century when tomorrow's domestic producers will need much better technologies to explore for remaining oil supplies, to characterize more difficult and complex U.S. reservoirs, and to drill for and extract oil supplies even more cost effectively. We will continue to study advanced concepts – such as cat-scanning and magnetic resonance imaging – that can image hydrocarbons and other fluids in reservoir rocks and lead to better production efficiencies. We will continue to work on innovations in longer-range production technology, such as advanced thermal flooding for heavy oil, microbial-biotechnology recovery, and new thermal and carbon dioxide flooding techniques for light oil fields.

Three-dimensional (3D) seismic depth imaging, in particular, can reveal untapped hydrocarbons. Bringing this advanced technique into greater use, however, demands extremely sophisticated technology and gigantic computing power. The know-how to make this possible exists in the United States; nuclear test computational expertise developed from our Cold War investments in our National Laboratories is directly applicable. For example, a joint project between Sandia National Laboratory and several computer companies has led to new computer code that cut computational time from days to hours. This unprecedented processing speed now makes it possible to search for oil and gas in regions that historically have been beyond the reach of conventional technology – for example, the potentially huge reservoirs that may lie beneath salt sheets in the Gulf of Mexico. We propose to continue the very successful national laboratory-industry partnership program, transferring our investments in national defense technologies to the production of domestic energy. In our FY 1997 partnership program, we propose to integrate high-performance computing technology into the ongoing national laboratory-industry activities.

Natural Gas and Petroleum Environmental Research - Lowering Compliance Costs Through More Reasonable Regulations

Improved technology is only one way to lower the costs of producing domestic oil and natural gas supplies. Equally beneficial may be reductions in environmental compliance costs. In 1984, the oil and natural gas industry spent $3.6 billion per year to comply with local, State and Federal environmental regulations. By 1993, compliance costs had risen to $10.6 billion per year. Over the next 5 years, new regulatory proposals could add another $14 billion per year. These added costs translate directly into lower domestic oil and gas production, especially from marginal properties.

The Nation, however, does not have to bear these huge economic burdens to have a clean, safe environment. Applying sound science, risk-based analysis, and credible methodologies can dramatically reduce compliance costs to industry without impairing public health and safety or endangering the environment. New, lower cost environmental compliance technologies can also reduce economic burdens and allow more dollars to be invested in actual oil and gas production.

The Federal Government has a unique and important role in developing mechanisms to streamline and improve existing regulations and laws as well as to ensure that future requirements are based on sound science. Our FY 1997 program places one of its highest priorities on showing State, local and Federal regulatory authorities how to protect the environment and at the same time, reduce compliance costs on our domestic industry.

This increased emphasis is the reason for the higher proposed budget levels for this program:

NATURAL GAS and PETROLEUM ENVIRONMENTAL RESEARCH (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	**FY 1997 Request**	Change from FY96
Natural Gas - Environmental Research/Regulatory Impact	$2.93	$2.95	**$4.65**	+58%
Oil Technology - Exploration & Production Environmental Research	4.69	5.46	**6.46**	+18%
Total, Gas & Oil Environmental Research	$7.62	$8.41	**$11.11**	+32%

In the **natural gas environmental research/regulatory impact** area, our efforts range from developing remote methods to detect natural gas leaks from pipelines to the pilot testing of more cost-effective techniques for treating and disposing of naturally-occurring radioactive material (NORM). The methane leak detection technology takes advantage of a government-developed innovation by Sandia National Laboratory for video imaging hydrocarbons. Its development will not only lower economic losses for the industry but also significantly cut atmospheric emissions of methane, a powerful greenhouse gas. Our research into the treatment and disposal of NORM will provide credible risk-based scientific information to State regulators (who are now developing requirements for NORM waste management), potentially lower the disposal cost of NORM waste from $1000 per barrel (of waste) to $300 per barrel, and demonstrate NORM disposal techniques that do not require transporting the waste off the property.

In the **oil technology environmental research program**, our goal is to lower the costs of complying with regulations for disposing of water and sand produced from oil/gas well operations, and to develop ways to better assess and mitigate the risks to groundwater from oil and gas operations. We also propose to expand our assistance to States in applying a nationally-developed methodology for assessing the risks of injection wells, ensuring that States have adequate tools to streamline and improve regulations. A national network of 25 States now exists to implement the DOE-developed, risk-based management system.

A key element in both the natural gas and oil environmental research area is an active outreach program with States, local agencies and producers. Although not a high-cost budget item, DOE's efforts to facilitate dialogue among producers and regulators has been highly productive in reducing institutional barriers and preserving U.S. oil and gas production while enhancing environmental protection.

We estimate that the oil and gas environmental research program, if funding can be sustained at the FY 1997 levels, can increase U.S. oil production, for example, by more than 200,000 barrels per day and natural gas production by 0.5 trillion cubic feet per year in 2015 through a combination of better risk assessment, regulatory streamlining, and lower cost compliance technology.

Downstream Research - Ensuring that Domestic Natural Gas and Oil Reaches Customers Efficiently and Affordably

While improved exploration and production technologies and cost-effective environmental compliance are crucial if the U.S. is to tap the full potential of its oil and natural gas resources, "downstream R&D" also offers opportunities for improvements that can increase the supply of domestically-produced energy reaching U.S. consumers.

The major elements of this budget are:

DOWNSTREAM RESEARCH (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	FY 1997 Request	Change from FY96
Natural Gas				
- Gas Storage R&D	$1.05	$1.07	**$1.00**	-7%
- Utilization (Low-Quality Gas Upgrading and Gas-to-Liquids R&D)	3.19	4.77	**4.84**	+1%
Oil Technology				
- Processing Research & Downstream Operations	$6.80	$5.70	**$5.96**	+5%
Total, Downstream Research	$11.04	$11.54	**$11.80**	+2%

Gas storage is the critical link between producers and consumers. It plays an increasingly significant role in the growth of the North American natural gas market, especially in the post-FERC Order 636 deregulation environment. Since 1990 use of gas storage to meet peak winter heating demands has increased 20%. Particularly for "nonfirm customers" – those who risk being cut off in times of peak gas demand – the speed and efficiency with which gas companies can extract natural gas from storage is extremely important. The responsiveness of storage fields to peak demands is both weather- and price-driven; however, improved technology plays a critical role in assuring that these fields can deliver when called upon. DOE's efforts in this area primarily support "cooperative research and development agreements" with industy to improve the design, development and flexibility in gas storage field operations.

The **natural gas utilization program** provides two approaches for ensuring that the Nation's gas supply is used to its full potential. More than 1/3rd of the natural gas in the United States is below the standards demanded for pipeline transport. The goal of DOE's low-quality gas upgrading program is to develop affordable technology that industry can use to can add as much as 750 billion cubic feet per year to the Nation's gas reserves by 2010. The gas-to-liquids program is targeted at producible gas formations that are too remote from pipelines to make production economical (such as Alaskan North Slope and deep offshore Gulf of Mexico gas). Research into lower-cost technologies for converting this gas into clean liquid transportation fuels could potentially displace as much as 500,000 barrels per day of imported oil by 2010. Early testing shows the potential for producing gas-derived fuels competitive costs and with an environmental quality superior to current least-polluting, oil-derived liquid transportation fuels.

Oil processing and downstream operations research is targeted directly at slowing the trend for crude oil to be processed overseas before being shipped to the U.S. Research that can assist refineries in complying with environmental requirements as well as reducing the formation of pollutants can have dramatic payoffs. America's economic growth will demand about 1 million barrels more refined product by the year 2000. At the same time, the domestic refining industry is being required to spend billions of dollars to comply with new environmental regulations. By developing better environmental data and technologies, we can assist industry in achieving superior environmental compliance while saving consumers millions of dollars. In addition, as U.S. crude oils become heavier and demand increases for lighter products (reformulated gasoline, oxygenated fuels, etc.), research that can increase the processing efficiencies of refineries can provide major, national dividends in terms of greater amounts of high-value, more affordable petroleum products.

Fossil Energy Management and Other Funding Requirements

In addition to the technology programs described above, the Fossil Energy R&D budget also contains funding for administrative and other expenses. As the following chart shows, these funding requirements have been significantly reduced in line with management streamlining, downsizing, and privatization within the Fossil Energy organization:

MANAGEMENT AND OTHER FUNDING REQUIREMENTS (Budget Authority - $ in millions)	FY 1995	FY 1996 Conference	**FY 1997 Request**	Change from FY96
Program Direction & Mgm't Support	$72.66	$66.60	**$57.16**	-14%
Plant & Capital Equipment	5.01	4.00	**3.30**	-18%
Environmental Restoration	15.30	14.92	**15.03**	+1%
Cooperative Research and Develop.	8.86	6.30	**4.00**	-36%
Fuels Programs (Regulatory)	3.00	2.69	**2.19**	-19%
Mining Research and Development	0	40.00	**5.00**	NA (transfer)
DOE-Wide Working Capital Fund	[4.27]	[4.33]	**2.95**	-17%

Note: Working capital fund figures for FY 1995 and FY 1996 are estimated for comparability purposes only.

Program Direction and Management Support provides Federal salaries and other expenses. The significant reduction from FY 1995 to FY 1997 reflects the consolidation of the Fossil Energy R&D field structure and personnel downsizing throughout our organization:

- At headquarters, salaries and travel expenses will be reduced by nearly 17% from FY 1995 levels, while contract support increases slightly as we must now budget for a prorata share of the maintenance and operation of the DOE-wide computer network.

- In our R&D field offices, salaries, benefits and travel expenses will decline by more than 18% from FY 1995 to FY 1997 while technical and management contract support will decrease by more than 57% due to the consolidation of administrative functions at our field centers. (This significant reduction is masked somewhat by the inclusion of $6 million in contract services for FY 1997 to pay transition costs associated with the privatization of the National Institute for Petroleum and Energy Research).

Plant and Capital Equipment funding provides for the continued upgrading of the Office of Fossil Energy's local area computer network, video conferencinng equipment (which is saving substantial travel costs), and other hardware needs. Also included is $2.3 million for general plant projects at our R&D field centers.

The **Environmental Restoration** budget funds the mandated cleanup of contamination at Fossil Energy sites and former Fossil Energy research and development projects, and ensures that our field facilities are in compliance with environmental, safety and health standards.

The **Cooperative Research and Development** budget provides Federal matching funds to the University of North Dakota Energy and Environmental Research Center and the Western Research Institute, permitting these former DOE facilities to attract private sector cost-sharing.

The **Fuels Program** budget provides the adminstrative expenses for carrying out legally required reviews of applications for natural gas imports and exports, exports of electricity, and the construction and operation of electric transmission lines across the U.S. border.

The **Mining R&D** budget proposal reflects Congress' action to transfer to the Department of Energy health and safety, materials, and mineral reclamation research activities of the Bureau of Mines. In FY 1996, these activities amounted to $40 million which was transferred to the Fossil Energy budget; in FY 1997, we propose to retain only the materials R&D effort, funded at $5 million, and transfer the health and safety program to the Department of Health and Human Services.

The **Working Capital Fund** is a new item being implemented DOE-wide in FY 1997. The fund will allocate costs to the program offices for rent, utilities, telephone and copier services, and other overhead charges previously funded in the Departmental Administration account. For comparison, pro rata estimates are shown for previous years.

THE CLEAN COAL TECHNOLOGY BUDGET REQUEST

The Department believes it can reduce the amount of funding currently appropriated by Congress for the Clean Coal Technology Program.

The General Accounting Office recently cited the Clean Coal Technology program as a model for successful public-private cooperation. One of the reasons why the program has become a government-industry "success story" was the willingness of Congress to appropriate in advance the full funding required for the Government's share of the jointly-financed, first-of-a-kind projects. This advanced appropriation of $2.55 billion has given U.S. companies sufficient confidence to sign cooperative agreements committing nearly $5 billion of their own funds to more than 40 projects.

Today, the most successful of these projects have established the technical foundation for a new era of high efficiency, environmentally clean energy production from coal. More than $9 billion in domestic and international projects are benefitting from the technologies demonstrated in the Clean Coal Technology Program. U.S. companies now can offer sulfur reducing technologies which are half the cost of previous technologies. NOx reduction technologies demonstrated in the Clean Coal Technology Program already have been retrofitted on about one-fourth of the Nation's coal-fired capacity.

Some of the remaining projects in the program, however, are likely not to complete their planned programs. In some cases, market conditions have changed; in other cases, the private sector partners have reevaluated their technology investment strategies. As a result, by the end of 1996, we expect that some projects will not go forward and others will be restructured resulting in significant cost savings.

Our FY 1997 budget proposal balances our need to maintain the Federal cost-sharing commitment to ongoing, viable projects, while at the same time, returning to the Treasury funding that is no longer needed and that can be used for deficit reduction.

We are proposing to rescind $325 million from funding previously appropriated for the Clean Coal Technology Program. The original funding level approved by Congress was $2.75 billion. In FY 1996, Congress approved a rescission of $200 million, reducing the total Federal funding to $2.55 billion. The FY 1997 proposed rescission would further reduce the Federal share to $2.225 billion. In addition, the Department is proposing to defer authority to spend nearly $313 million of available funds until FY 1998. Given that virtually all final project funding decisions will be made by the end of 1996, we should be in a position to recommend to Congress whether all or part of the $313 million in deferred spending authority will be needed in FY 1998 to meet prior Federal commitments.

The Clean Coal Technology funding profile is:

CLEAN COAL TECHNOLOGY (Budget Authority - $ in millions)	FY 1995	FY 1996	**FY 1997**	FY 1998
Previously Appropriated Funding	$36.28	$150.00	**$137.88**	
Proposed Rescission			**-325.00**	
Delay in Obligational Authority			**-312.88**	+$312.88
New Funding Profile			**-$500.00**	+$312.88

CONCLUSION

The Office of Fossil Energy has made many difficult but necessary decisions in developing its FY 1997 budget. While it meets Congressional guidance in terms of fiscal constraint, appropriateness of the Federal role, and management streamlining, this budget proposal should continue to be seen as a transition:

- In the R&D program, we are transitioning from an engineering-dominated program to a more fundamental, core science and technology program. Planning is underway to define this core program for the post-2000 timeframe. Meanwhile, it is important that we continue to capture the benefits of investments made to date in technologies that are only 2-4 years away from realizing their R&D goals.

- In the Clean Coal Technology Program, we are entering the final phase of federal funding. Most of the early projects have completed their demonstration phase; several of the more recent, larger scale projects are in construction or operations. The Federal role soon will be concentrated solely on monitoring the Federal investment and ensuring that the Nation benefits to the greatest extent possible from these first-of-a-kind technologies.

These transitions are bringing profound changes to the way the Office of Fossil Energy looks and operates. The commitment of both the Congress and the Administration to proceed with this transition in the most rational and responsible manner possible is critical if we are to maintain a focused, efficient, and effective Fossil Energy program that truly benefits this Nation.

We look forward to writing this new chapter for Fossil Energy in collaboration with this subcommittee.

Mr. Chairman, that completes my prepared statement.

Chairman ROHRABACHER. Ms. Godley, thank you very much. Mr. De Gennaro.

STATEMENT OF RALPH DE GENNARO, EXECUTIVE DIRECTOR, TAXPAYERS FOR COMMON $ENSE, WASHINGTON, DC

Mr. DE GENNARO. Thank you, Mr. Chairman. My name is Ralph De Gennaro. I am Executive Director and co-founder of Taxpayers for Common $ense.

We are a new taxpayer organization dedicated to cutting government wasteful spending, subsidies and tax breaks and balancing the budget. We are politically independent and seek to reach out to taxpayers of all political beliefs to build support for common sense solutions.

We have been invited to offer our views on three particular programs under the jurisdiction of the Committee—the Clean Coal Technology program, the Coal R&D program, the Petroleum R&D program. In short, we support eliminating all of them.

All three of these programs were highlighted in a report called "Green Scissors '96," which was published on February 15th of this year. This is the report. Some of you may be familiar with it.

The principle of "Green Scissors" is to bring together an odd couple coalition of taxpayer groups with environmental organizations to agree on a set of cuts that can be made. "Green Scissors" is one way to get at some of the goals we need to reach if we are going to balance the budget.

I should make clear that I am testifying today on behalf of our organization and not on behalf of the coalition, which has a variety of views on a variety of subjects. However, the "Green Scissors" report recommended getting rid of all these programs.

Taxpayers for Common $ense ultimately favors leveling the playing field and eliminating subsidies for all energy sources and efficiency as well as all energy tax breaks. Taxpayers for Common $ense believes that the first targets should be those energy industries that are most mature economically and that have historically received the most subsidies.

Certainly, fossil fuels is mature and has received more than its share of subsidies in this century.

I respect the individuals at this table. They are doing their best. And, we have no gripe with their performance or their efforts on behalf of their agencies.

However, it's time to be honest, Mr. Chairman. These programs are all corporate welfare that we can no longer afford.

And, that goes if it's the Babcock and Welfare Company, if it's the Houston Lighting and Welfare Company or if it's the Solar Energy Welfare Association. We can't afford any of them anymore. We have got to get rid of all of them.

Just summarizing some of the specifics in the testimony, the Clean Coal Technology program was started a long time ago as a way of cleaning up emissions. With the passage of the 1990 Clean Air Act, companies have other incentives to meet these goals.

The Coal R&D program supports an industry that is mature and that can afford to pay for its own research. There is no reason taxpayers should be paying for this program.

The Petroleum R&D program benefits corporations like—and listen to this list—Exxon, Chevron, Conoco, Texaco, Amoco, Philips Petroleum, ARCO, Shell, Schlumberger and Marathon Oil. It's not right for hard-working folks to go to work everyday and pay taxes to give money to companies like this.

They don't need it. Or, if they do need it, if these companies are that dependent on the Federal Government, we have another kind of problem.

We would note, with compliments to the Department of Energy, that the funding has been going down for these programs in recent years. And, the Energy Department has proposed cutting them more this year. We would encourage that direction and phase them out as quickly as possible.

Thank you very much.

[The prepared statement of Mr. De Gennaro follows:]

TAXPAYERS FOR
COMMON $ENSE

Testimony of Jill Lancelot, Legislative Director
Taxpayers for Common $ense
before the House Committee on Science
Subcommittee on Energy & Environment
April 17, 1996

Good morning. My name is Jill Lancelot and I am the Legislative Director and co-founder of Taxpayers for Common $ense. Taxpayers for Common $ense is dedicated to cutting wasteful government spending, subsidies and tax breaks through research and citizen education. We also support a balanced budget for this nation. We seek to reach out to taxpayers of all political beliefs in working towards a government that costs less, makes sense and inspires trust. Taxpayers for Common $ense is non-profit, non-partisan and independent.

We would like to thank the committee for giving us the opportunity to present our views on three fossil fuel programs. The Clean Coal Technology Program (CCTP) and the Coal Research & Development and Petroleum Research & Development (R & D) programs provide funds to private industry through the Department of Energy (DOE). Taxpayers for Common $ense opposes these programs because they are a waste of taxpayer dollars. All three programs were highlighted in the *Green Scissors '96* report which we co-authored in February of this year.

Taxpayers for Common $ense ultimately favors leveling the playing field and eliminating subsidies for all energy sources as well as energy tax breaks. TC$ believes that the first targets should be those energy industries that are most mature economically and that, historically, have already received the most subsidies. Certainly, fossil energy subsidies are high on that list.

Clean Coal Technology Program

Under the Clean Coal Technology Program, DOE awards bids to companies for the development of cleaner-burning coal technologies. In addition, DOE provides up to fifty percent matching funds to industry for demonstration projects. The program's original total appropriation of $2.75 billion was reduced slightly in 1995 through a rescission of $200 million. A total of $2.55 billion has now been appropriated to support all selected projects to date. Of that total, $1.5 billion has been obligated. For FY96,

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Congress made $150 million available for clean coal, even though the Administration requested only $45 million.

There is no reason for the federal government to spend this kind of money on clean coal research. When the program was begun in 1986, its mission was to assist in the development of commercial technologies to reduce air pollution. However, the passage in 1990 of the Clean Air Act, which requires companies to meet federal emissions standards, has to a large degree made federal support for this kind of development unnecessary. This fact was cited by the Penny/Kasich Bipartisan Task Force in 1993 in their "Common Cent$ Plan" for cutting federal spending. That report recommended termination of the CCTP.

Advances in emissions reductions can and should be made by the private sector. For example, high sulfur coal producers conduct independent research in this area in order to maintain their competitiveness in the market. The U.S. General Accounting Office (GAO) found that DOE funded several technologies that would have been successfully commercialized without federal assistance. In one particular instance, the GAO reported that "project participants were already undertaking substantial efforts to market the technology and had established business relationships with potential users." DOE funded the project anyway.

It should also be noted that the CCTP has a history of waste and mismanagement. In 1991, the GAO determined that nearly half of the projects funded under the program had either "fallen behind their scheduled milestones, incurred cost overruns, and/or scaled back the scope of their planned work...." The GAO also pointed out that 13 projects were actually withdrawn from the program entirely because of "financing and other problems" even though DOE had already invested approximately $21.2 million in five of these projects.

TC$ urges DOE to phase out the Clean Coal Program by canceling those projects on which construction has not yet begun or will not begin for more than five years after the project selection date. This would save more than $912 million over the next five years, according to publicly available information on the funding status of CCTP projects. At the very least, TC$ supports the current Administration proposal to rescind $325 million from the program and hopes that the Administration will request no funds for FY98.

Coal Research & Development

In addition to the Clean Coal Technology Program, DOE also maintains the Coal Research & Development Program which funds research for coal production, refinement, and burning technologies. Congress continues to hand out well over $100 million in research subsidies every year to the multi-billion coal industry. In FY95, the appropriation was $154 million, in FY96 it decreased slightly to $121 million. In the last several years, Congress has consistently appropriated more money for the program than the Administration has requested. In 1993, funding was $50 million higher than the President's request, in 1994, it was $20 million higher and in 1996 it was $7 million higher.

American taxpayers should not be footing the bill for a mature industry that can afford to fund its own research projects. Besides being inappropriate, federal funds are often redundant as both the utility and coal industries already invest heavily in developing new technologies that will keep them competitive. In addition, the Congressional Budget Office has written that DOE funds research into unpromising technologies, stating that "DOE continues to develop technologies in which the market clearly has no interest." As an example, the CBO points out that "DOE spent hundreds of millions of dollars on coal-powered magnetohydrodynamics – without any indication of who was interested in the product."

The FY97 request for coal R & D is currently $102.6 million. We urge the Committee to consider carefully the appropriate role for the federal government in financing coal R & D and hope that this program will be terminated.

Petroleum R & D

DOE's petroleum R & D program provides funds for enhanced recovery, exploration and refinement of crude oil. Corporate recipients include: Exxon, Chevron, Conoco, Texaco, Amoco, Philips Petroleum, ARCO, Shell, Schlumberger, and Marathon Oil. These large companies, many of them highly profitable, do not need the American taxpayer to pay their R & D costs. In fact, DOE's involvement may compete with private companies that provide recovery and exploration services.

DOE has taken a step in the right direction and did request fewer funds for FY96 for petroleum R & D than it did in FY95. Still, the program is slated to receive $55.7 million in FY96. As the Committee knows, this funding is based on the current continuing resolution and the actual funds have not yet been appropriated. Again, we would hope to see this program's termination this year.

It is important to realize that ending DOE-funded petroleum R & D would not mean an end to this kind of research. The prime beneficiaries of the program are companies large enough to conduct their own research and development. In fact, the Congressional Budget Office writes that "In the area of fossil energy R & D . . . commercial firms already spend a great deal of money to develop new technologies. The major new technologies for enhanced oil recovery . . . have come from private industry, not DOE." The Penny/Kasich report mentioned earlier also calls on DOE to cut back funding for this program, stating that "commercial firms already spend considerable funds to develop new technologies."

Conclusion

In conclusion, I would like to remind the Committee that this Congress and the President have both committed to balancing the budget. Taxpayers for Common $ense applauds that decision and offers the three programs described above as targets for potentially significant savings. The federal government cannot afford to continue massive subsidies to industries that are quite capable of supporting themselves in the area of research and development.

A look at funding levels for fossil fuels research over the past several years shows that federal handouts to coal and petroleum research have been steadily declining. We urge the Committee and the Department of Energy to continue this trend and end all subsides for the clean coal technology project and coal and petroleum research and development programs.

Thank you.

Chairman ROHRABACHER. Mr. Rackley.

STATEMENT OF JOHN M. RACKLEY, VICE PRESIDENT, RESEARCH AND DEVELOPMENT, McDERMOTT, INC./BABCOCK AND WILCOX COMPANY

Mr. RACKLEY. Thank you, Mr. Chairman. I am John Rackley, Vice President of Babcock and Wilcox's Research and Development Division.

You should understand that we are the centralized research division for McDermott, Incorporated, of which B&W is a part. I am a corporate officer of McDermott.

I am not a PhD. I am the son of a West Virginia coal miner who got a college degree and has been working in this field for 42 years.

I have submitted expanded comments. And, I understand and accept that you will put it in the record.

Chairman ROHRABACHER. Yes, without objection.

Mr. RACKLEY. Let me give you a little overview of what I had to say. We have very extensive contacts with both U.S. and foreign organizations.

Several things are apparent to me from these contacts. Among them are. American technology establishes U.S. product credibility in foreign markets.

We are in a global competition for many external markets. We need to win to protect U.S. jobs and our standard of living.

Foreign countries are subsidizing their companies by adding tremendous resources to support the development of products and, in some cases, commercialization of products for the same global markets for which we compete.

And, regardless of what some people may say, there's no better place to live than the U.S.A. and it's always really nice to come home.

Now, we all know that Monday was April the 15th. That's when I and a lot of my fellow citizens really start to wonder just how well our hard-earned dollars are being used by our elected representatives. So, you have my support in reevaluating the budget to assure that our tax dollars are used in a responsible way.

One of the jobs that I have in my company is to try to make sure we make the right decision. We must resist a hasty decision for the short term and, consequently, sacrifice the long term.

On the other hand, we have to have the character and strength to stop when it is obvious that real progress is unlikely. But, even when we do stop, we try to make sure that we do it in an orderly manner where progress is brought to a logical conclusion and reported so that the effort can be restarted should the situation demand.

I would encourage you, when you identify programs which are candidates for reduction in federal funding, to resist the temptation for a meat axe type termination scheme. I think the taxpayers deserve to derive the benefits that may be realized through well-managed phasing down of projects rather than arbitrary terminations.

Let me say that I have worked very closely with many people from DOE. Let me also say that I believe that they have been very good stewards of the resources you have placed with them.

Let me briefly mention some of the program areas we have or have been working in. In fossil energy, we have partnered with DOE in the clean coal, in advanced clean and efficient power programs.

As detailed in my written comments, some of these initiatives have led to very good commercial successes. For example, we have sold over $200 million worth of burners that reduced nitrogen oxide emissions from power plants by about 50 percent. Components for these things are supplied from five different states.

We can point to examples in energy conservation that are a little further away from commercial reality such as the development of continuous ceramic composite fibers. Because they potentially can be used at higher temperatures than metals, we might be able to realize very huge savings in energy and reductions in undesirable emissions by 2010.

We are also exploring innovative, inherently safer gasification concepts for recovery of the chemicals used in the wood pulping process. This is part of the Agenda 2020 Forest and Paper Products program.

Partnerships with DOE are essential in bringing such products and potential products to the stages of high risk research and development before we can commercialize them for the domesticate and international marketplace. Now, let me assure you that I'm not looking to DOE to give me a competitive edge over my domestic competition. It's my ingenuity that must do that.

U.S. companies do need U.S. government agencies to create a level playing field for the global market of the 21st century. If we don't get it, we and my domestic competitors stand the high probability of losing out in the international market and perhaps our domestic market also.

In summary, I urge you to reevaluate, re-size, refinance, if necessary, but don't forget that there is a need for basic research support and support for the linkage steps that turn that basic research into products and processes. The technology edge and real application is the key to well paying jobs of tomorrow.

The civilian technology programs that are funded and sponsored by DOE are important to our nation's future and to obtaining national goals of energy independence, environmental protection and economic well-being.

Now, let me close my statements with a thought I recently gave to my Chief Executive Officer and his staff when I presented my comprehensive business plan. And, that is. R&D is an investment, not a cost.

Ladies and gentlemen, I believe that DOE programs are an investment in the future of the United States.

Thank you.

[The prepared statement of Mr. Rackley follows:]

TESTIMONY TO THE SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

HOUSE COMMITTEE ON SCIENCE
FROM MCDERMOTT INC., INCLUDING BABCOCK AND WILCOX CO.

Presented by Mr. John M. Rackley
Vice President, Research and Development
April 17, 1996

Mister Chairman and Committee Members:

McDermott Inc., and Babcock and Wilcox Company (B&W), its largest subsidiary, appreciate this opportunity to present testimony in support of the U.S. Department of Energy's civilian research and development in fossil energy and related program arenas. As witnessed by our own experiences and those across a wide spectrum of the energy industry, initiatives cosponsored by the Department of Energy have provided, and should continue to provide, effective means to address the serious national challenges of energy security, environmental quality, and economic well-being.

INTRODUCTION

McDermott / Babcock and Wilcox

McDermott Inc. is a world wide leader in the supply of energy services and systems. We operate two major business segments: power generation systems and equipment, and, marine construction services. The principal businesses of the power segment are the supply of fossil-fuel and nuclear steam generating systems and equipment to the electric power generation industry, and nuclear reactor components to the U.S. Navy. Marine construction services supplies services for the offshore oil, natural gas and hydrocarbon processing industries, and to other marine construction companies. These include marine pipelines, offshore structures, subsea production systems, and onshore construction and maintenance services. Our annual sales are typically $3 billion. Of this, slightly more than half is typically for foreign markets. Our total employment is about 25,000, of which 13,000 is in the U.S.

B&W has provided boilers since the industrial revolution. It has sustained its leading role in the supply of steam, power, and environmental control components through continuous technological innovation.

Our company typically conducts between $40-50 million annually in research at the central research and development division, which I manage. Similar amounts are spent within our operating divisions. We have had, and plan on continuing, a very constructive cooperative relationship with the Department of Energy on a variety of technology initiatives. These programs have been beneficial for our company and for our country.

General Comments on Federal Technology Funding

We wish to offer a few overview comments regarding federal funding for industrial research.

We are keenly aware of the need to seriously address our nation's debt problems. A debate is underway, both philosophically and as part of the national debt considerations, on what the federal government role should be, beyond basic research, in private sector technology development. Strong arguments are being made from all perspectives on this important public policy issue, and we believe that the open airing of differing views is constructive. In your considerations of the issue generally, and Department of Energy program authorizations specifically, please be realistic about the impact of technology on the ability of U.S. companies to successfully compete in the global economy of the 21st century. It is vital that you factor into your decision-making the international competitiveness implications of foreign governments' actions. Sustained support for their companies' technology efforts by the governments of Japan and Western Europe, for example, would threaten the competitiveness of U.S. companies in the international marketplace, if U.S. government support is unilaterally withdrawn.

We believe that the potential exist for some constructive reductions in federal support for our nation's technology programs. They need to make sense, and be implemented in a well managed, wind-down manner. Arbitrary project terminations that run counter to the intent of the program commitments by both the government and non-government participants, would be inefficient, create ill will, and deprive the taxpayers of the benefits that would have been derived by a controlled phasing down of the initiatives.

Our company is not blind to the business opportunities that technology breakthroughs can provide. However, in the absence of additional incentives, the tug of competing needs for limited capital presents a severe challenge to the commitment of private resources for risk-laden technology development efforts. From our own company's actions, we can state without equivocation that relatively small magnitudes of federal funding can provide great leverage for the government to direct private sector resources toward the resolution of serious national problems. We believe that it is appropriate and responsible for the government to provide the kinds of help . proposed in the Department of Energy's civilian research budget proposal.

PROGRAM EXAMPLES

In the following sections, we present real-world examples from our company's participation with the Department of Energy. The examples cover the range of maturation of technologies, from initiatives that have already progressed from the research stage into commercial products, to potential initiatives that are currently little more than research concepts. We hope that this testimony will contribute to the appreciation for the potentially constructive impact of government funding for research in fossil energy, and similar, programs. Without Department of Energy participation in these program areas, the technologies would either have not been pursued, or would have developed at a much slower rate. Either non-development or severely delayed development would have adverse outcomes for our country's energy, environment, and jobs scenarios.

Low-NOx Burners

B&W has been a developer and provider of leading edge NOx reduction technologies since the advent of our nation's environmental movement. The focus on NOx reduction intensified during the considerations in 1980 of the Clean Air Act Amendments. In the first round of the Clean Coal Technology Program in the mid-1980s, DOE awarded $7.6 million in cofunding for an $19.8 million project that carried forth progress made on the development of a limestone injection multi-stage burner system. This technology, the DRB burner, which stemmed from prior B&W research, promoted reductions of up to 60 percent in NOx and SO2 emissions in old boilers through cost-effective retrofit modifications to existing facilities. In the third round of the Clean Coal Technology Program, DOE awarded $5.4 million toward an $11.2 million project to conduct the first commercial-scale full burner retrofit reduction of NOx from a large coal-fired base-load utility boiler with B&W's Low-NOx cell burner technology. This project, which included eight additional team members, operated on the principle of staged combustion to attain 50 percent reductions in NOx emissions without otherwise affecting boiler performance.

These projects are completed. DOE cofunding for these B&W Low-NOx burner technology developments has come to an end. In addition to the energy independence and environmental implications of these capabilities, there are tangible domestic economic benefits. The successful results of these technology development and demonstration programs have resulted in real commercial success stories. B&W's DRB burner sales are $240 million; providing 23,700 MWe capacity, of which 14,300 MWe are international and 9,300 MWe are domestic. DRB burners are in 101 boilers. The newer Low-NOx cell burner product sales have been $27 million, representing 4,900 MWe, all of which are in the domestic facilities. U.S. employment in the production of the burners has been 1700 employee-years. Components are provided from facilities in five states.

Low Emission Boiler Systems

The Low Emission Boiler Systems (LEBS) program is an example of an important DOE fossil energy program in progress. Research is well underway, offering the promise of significant progress toward the goal of clean combustion of coal, our nation's most abundant indigenous fuel. For at least the next decade coal is projected to continue to be the fuel source for over half of our nation's electric energy generation; generating 1773 billion Kwh of electricity, or 53.6% of the projected total in 2005.

In 1990, the U.S. Department of Energy initiated a program entitled Combustion 2000. The LEBS program, one of the principal parts of Combustion 2000, is to develop an advanced pulverized coal (PC) fired power generation system for commercial application by the year 2000. LEBS may be viewed as one of three classes of advanced technologies being developed for substantial improvement in energy and environmental performance of coal-fired power plants. The other advanced technology classes for coal-fired plants during this time period are pressurized fluidized bed combustion and integrated gasification combined cycle systems.

LEBS program criteria are directed toward very low emissions and high cycle efficiency at a life cycle cost equivalent to a conventional PC plant meeting New Source Performance Standards (NSPS). Environmental missions include sharply reducing constituents associated with acid rain, global climate change, ozone depletion, and solid waste. Due to advances in emission control technologies, the goals of the LEBS program have been made more stringent since initial work began in 1993. The present program targets are: no more than 0.1 lb/MBtu NOx, no more than 0.1 lb/MBtu SO2, no more than 0.01 lb/MBtu particulate, net plant efficiency preferable above 38% (HHV), reductions in solid wastes, and compliance with anticipated air toxics regulations at or below the cost of electricity of a conventional NSPS plant. Great progress is being made toward attaining the objectives.

Three industrial teams are engaged in developing a low emissions boiler system. The program is structured in four phases to be executed over a seven year period. Phase I, completed in 1994, involved system analysis, R&D planning and component definition resulting in a preliminary commercial generating unit design. In Phase II, currently underway, involves pilot and subsystem scale testing. Phase III is the development of the design, and plans for construction and testing of a Proof-of-Concept (POC) demonstration facility. We support DOE's request for $5.5 million in fiscal year 1997 to complete the Phase II and Phase III activities. Finally, a down-selection process will identify one contract team for Phase IV, involving construction and operation of the POC facility. Costs for the phases are: Phase I $3.8 million, provided by DOE; Phase II $9.7 million DOE, $12.9 million total; Phase III $0.8 million DOE, $1.1 million total. Phase IV costs, which are uncertain, may total $40 million, with cost sharing of 50 percent from DOE and 50 percent from B&W and others.

The opportunities for commercial deployment of successfully-developed LEBS technologies are very large, as are the potential environmental and energy security benefits. Domestically, there are more than 1200 utility-owned coal-fired power plants representing 323,000 MWe or about 44 percent of total U.S. generating capacity. By the year 2005, 647 units representing 74,000 MWe will be older than 40 years. Utilities have announced plans to repower about 6,300 MWe and a need for about 6,800 MWe of new capacity. In the total domestic market, the opportunity exists for installing over 15,000 MWe of advanced coal-burning technologies in the next decade. Globally, about 300,0000 MWe of coal-fired capacity is expected to be ordered over the next decade. Much of this will be Asia and the Pacific Rim.

Given this commercial incentive, one might question the need for government support in promoting technology development. In the U.S., economic pressures and uncertainties associated with utility industry deregulation, uncertain long-term environmental requirements, and other issues encourage investment in power plant incremental improvements and inhibit large investments in higher risk technologies. In order to gain acceptance in the marketplace, any new coal-based technology must overcome the risks inherent in the first units while achieving capital costs comparable to conventional coal-fired technology. The hurdles of the U.S. energy scenario make it difficult without outside support to bring substantial innovations to commercial fruition. Government-industry cooperative programs, such as those supporting PFBC and IGCC development (largely in the Clean Coal Technology Program) and LEBS (in Combustion 2000) remain a critical part of our nation's effort to promote the use of coal in an environmentally acceptable manner.

The situation in technically sophisticated foreign markets, notably in Japan and Western Europe, stands in stark contrast to that in the U.S. These countries are promoting the development and commercialization of advanced technologies due to a combination of factors that include high fuel costs, immediate demand for new capacity, government incentives for emissions reductions, government support for technology development, and government subsidies to offset the added costs and risks of initial commercial installations of advanced technologies. Without substantial progress in the U.S., our foreign trading partners will be positioned to offer advanced coal-fired power generation technologies, based on actual learning curve experience, both in foreign markets and in the U.S. market, as it materializes. Technologies initially developed by U.S. companies may be commercialized by foreign companies.

Advanced Emissions Control Development Program

The Advanced Emissions Control Development Program (AECDP) is an ongoing program aimed at reduction of emissions of air toxics by utilities and other coal-fired steam generators. It is a program for which a great deal of pre-planning and facility investment have already been done. We are currently ready to launch into the actual research activities of the AECDP.

As a necessary precursor to the conduct of the project, our company committed over $17 million of its capital to build a 100 MBtu/hr Clean Environment Test Facility (CEDF). These funds were supplemented by a combined share of $4.2 million from Ohio Coal Development Office and DOE. The CEDF is a world-class combustion and environmental control research facility commissioned in fiscal year 1995. The facility was intentionally designed to provide a test bed for conducting air toxics emissions work that can be reliably applied to full-size power plant plants.

The AECDP is a five year effort that began in 1993. Facility modification and equipment installation, benchmarking, development of air toxics data library, and other Phase I activities are complete. Baseline air toxics emissions and capture efficiency were established for each of the major flue gas cleanup devices. All tests were conducted with a representative U.S. steam coal. Phase II and Phase III will be directed at optimization of conventional systems and research into advanced concepts, respectively. A goal is improved understanding of the mechanisms and dynamics of evolution of air toxics from the coal into the gas stream. The scope extends to basic coal characteristics and coal cleaning impacts, to air toxics emissions measurement and monitoring technology, as well as to gas stream handling and contaminant removal systems.

The House-Senate conference for fiscal year 1996 appropriations for Interior and Related Agencies allocated $1.8 million in DOE's fossil energy program for work on Phases II and III of AECDP. We are prepared to complete the project with those funds. Presuming the fiscal year 1996 funds are provided, no additional appropriations in fiscal year 1997 (or subsequent years) should be required to finish the program. We anticipate finishing the project work around the end of calendar year 1998. We believe that the program will be seen as having contributed to the knowledge base for protection of public health and the environment; provided an air toxics data base that will be used by U.S. utilities, industry, universities, and other organizations; facilitated continued use of U.S. coal reserves for electric power generation and other uses in a cost-effective, environmentally sound manner; and contributed to market share for U.S. equipment manufacturers in the global energy market.

Conservation Programs

The Industries of the Future Program provides an evolving model that promises critical technological innovations for important sectors of our nation's economy. A key to this government-industry cooperative arrangement is the role of industry groups in the determination of program objectives. The system is designed to provide, on an evenhanded basis, highly-leveraged government support for base technology initiatives that enable large, energy-intensive domestic industry segments to enhance their international competitiveness. The structure attempts to avoid the pitfalls of government selecting winners among domestic competitors, as industrial teams participate in defining key technology needs. B&W has interests in several of the initiatives within the Industries of the Future Program. Two of these are the Continuous Fiber Ceramic Composite Program, a cross-cutting initiative, and the Agenda 2020 Forest and Paper Products Program, an industry specific initiative.

The Continuous Fiber Ceramic Composite (CFCC) Program is founded on the principle that operating efficiencies for high temperature processes are limited by temperature constraints. Step changes in efficiencies should be attainable through marked increases in temperatures. For the United States to remain a world leader in the manufacture of power generation equipment, the industrial manufacturing base has a critical need for materials that are corrosion resistant and strong at high temperatures, lightweight, and cost effective. Many ceramics perform well at considerably higher temperatures than metal alloys, but they are generally too brittle for reliable performance and tend to fail in a catastrophic manner. By reinforcing ceramics with continuous fiber, significant toughening occurs so that the benefits of ceramics can be achieved while reducing the risk of component failure in service life. This emerging class of material is CFCCs.

In 1992, the Department of Energy initiated a 10 year joint development effort between industry, academia, national labs, and government to develop cost effective CFCCs for industrial applications. Implementing CFCC materials in industrial applications will result in energy savings and emissions reductions. By the year 2010, the benefits due to the CFCC program are projected to include: energy savings of $10.5 billion, reductions of about a million tons of NOx and 120 million tons of carbon dioxide emissions. Component sales to support these reductions are predicted to be $850 million.

B&W leads one of the CFCC teams in this program. Our applications for these materials include components for more efficient and lower emission coal fired power generation equipment, gas turbine components, systems for the chemical process industry, and components for improved waste incineration. The manufacturing base for this technology has emerged as a result of defense conversion efforts within the company. On the team with B&W are industrial partners, materials suppliers, universities, and state government agencies. Program costs through early 1996 have been $3.2 million DOE of $3.8 million total. For the present period, ending March 1997, cost shares are to be $0.8 million DOE of $1.1 million total.

Another part of DOE's Industries of the Future Program is the Agenda 2020 Program for the Forest and Paper Products Industry. This industry is important to our nation. Pulp and paper manufacturing employs over 620,000 people, in well-paying manufacturing jobs. The value of industry shipment totals over $135 billion -- including over $12 billion in exports. There are over 350 pulp mills and over 600 paper and board mills located throughout the U.S. These provide the materials to many additional facilities that convert the output of these mills into final products and distribute those products to wholesale and retail outlets.

The industry is one of the country's most capital intensive manufacturers, ranking second in total capital expenditures among manufacturers -- thus requiring significant support from domestic capital equipment suppliers. Energy costs represent approximately 8 percent of the value of shipments. These cost are kept low primarily by the industry's investment in self-generation. Today it produces over 50% of the energy used, much of it as a byproduct of chemical recovery operations for pulping and by using renewable, waste fuels.

The Agenda 2020 government-industry team has identified six high priority research areas for the forest and paper industry. These are: sustainable forest management, environmental performance, energy performance, improved capital effectiveness, recycling, and sensors and controls. B&W has business interests in several of these areas, including energy, environment, and capital effectiveness. Some of our on-going projects that directly relate to Agenda 2020 include: black liquor gasification, kraft recovery process improvements, and sensors for improved chemical recovery operations.

There are over 200 operating recovery boilers in the U.S. today that provide the current approach to chemical and energy recovery in the pulp and paper industry. This equipment represents the largest single block of capital equipment required to for an operating pulp mill. The aging recovery boiler capacity in the U. S., combined with the need for new capacity is expected to result in the need for up to four large recovery boilers or a 2% per year of this equipment.

B&W and DOE have an on-going cooperative program that is currently investigating a novel approach to black liquor gasification, as an alternative to the conventional recovery boiler system in which black liquor is combusted. This innovative concept should afford improvements in system energy efficiency, reductions in emissions, and safer working conditions. We are currently preparing bench-scale equipment to fundamental studies in the laboratory for this design. If successful, the logical next step would be to extend the concept to pilot scale. The pre-commercialization pilot phase funding might involve several million dollars through Agenda 2020 that would be matched by non-DOE funding.

SUMMARY

Many of the civilian technology programs that are cosponsored by the Department of Energy provide highly leveraged investments for our nation's future. Well-run initiatives result in technological achievements that contribute significantly to our energy security, environmental quality, and economic health.

Our ability to succeed in the environment of global competition of the 21st century will depend more than it ever has on the maintenance of a technological edge. Governments of our trading partners continue to support the industries that they perceive to be critical to their futures. We commend the idea of searching to identify opportunities to reduce the federal deficit, including reductions in technology program funding where appropriate. We are very concerned that a disproportionate reduction of U.S. government support for domestic civilian technology efforts will adversely affect our technological strength relative to that of foreign competitors. An inevitable result of disadvantage in technology in the global marketplace is loss of global market share. Diminished domestic employment standards would result as well-paid technology-based production and service jobs leave the U.S.

Conversely, through constructive cooperative relationships among private companies, government, and universities, we have the capability to flourish in the 21st century. Many of DOE's programs have effectively contributed to our nation's well-being. With changes corresponding to tomorrow's challenges, we believe that the energy, environment, and economic future of our country can be bright. Cooperative technology initiatives, such as those supported through DOE's civilian research and development programs, can have a vital impact on our well-being.

Chairman ROHRABACHER. Thank you very much. And, I would now like to yield some time to Mr. Roemer, a very able Minority leader here and Ranking Member.

And, perhaps you would have a special introduction to make.

Mr. ROEMER. Thank you, Mr. Chairman. I would like to welcome Mr. Tees to Capitol Hill and welcome his testimony to our panel today.

Mr. Tees, as you know, the very able and distinguished gentle lady from Texas, Ms. Sheila Jackson-Lee, is not with us here today. She was very instrumental in helping get your expertise here before the Committee to testify.

I want to personally welcome you on behalf of her and on behalf of the Committee. We look forward to your testimony and the opportunity to ask you some questions.

Certainly, your resume is very impressive. You are Vice President of Energy Production with Houston Lighting and Power Company. You have a half dozen professional advisory positions in addition to being involved in other important things in the community.

I salute you for all that. And, I do want to kid you a little bit, especially since Ms. Jackson-Lee is not here.

Being somebody that is from South Bend, Indiana and who attended Notre Dame, I just wish you had maybe attended—after going to Texas A&M for undergraduate that you might have picked Notre Dame to go to for graduate school. But, since you picked Texas A&M both times, one of our football rivals, certainly we still welcome you here to this Committee and look forward to your testimony here today.

And, I thank you, Mr. Chairman.

Chairman ROHRABACHER. Mr. Tees, you may proceed.

STATEMENT OF DAVID G. TEES, VICE PRESIDENT OF ENERGY PRODUCTION, HOUSTON LIGHTING AND POWER COMPANY, HOUSTON, TEXAS

Mr. TEES. Thank you, Mr. Roemer. We, at least, sent you a good coach up from A&M.

And, Mr. Chairman——

Mr. ROEMER. And, he has done a great job, Mr. Tees. And, if you have any more coaches, please continue to send them up.

[Laughter.]

Mr. TEES. My name is David Tees. And, I am Vice President of Production at Houston Lighting and Power Company. And, I really appreciate the opportunity to speak today.

HL&P is a regulated, investor-owned utility. And, we supply power to about three million people in the Houston, Texas area.

We own 10 generating stations. And, we generate almost 15,000 megawatts, utilizing lignite, western coal, natural gas, oil and uranium.

The purpose of my testimony today is to offer a perspective on the value of Department of Energy research in fossil energy. While this perspective reflects the experience of Houston Lighting and Power Company and my 30 years with the company, I hope to offer a wider perspective due to my position on these committees that were mentioned.

I am on the Electric Power Research Institute Research Advisory Committee, the EEI Generation Subject Area Committee and the Advisory Committee to the DOE's Advanced Turbine System.

Houston Lighting and Power has a long history of involvement in and funding of research and technology development focused on improved service in the utility industry. Over the last 10 years, we've invested over $100 million in R&D.

We've actively worked to deploy energy conservation technologies using materials developed under DOE's energy efficiency and renewable energy program. In 1994, we received a National Award for Energy Efficiency and Renewable Energy for our commercial cool storage program.

We participate in many collaborative research efforts, the primary one being collaborative funding of research programs connected and conducted by the Electric Power Research Institute. EPRI has an annual budget of about $500 million and a focus on research and technology issues pertaining to electric generation, transmission, distribution, environmental compliance and end use of electricity.

In late 1994, EPRI and the Department of Energy entered into the sustainable electric partnership with the goal of streamlining communications and maximizing collaborative funding and increasing the effectiveness of both organizations. To date, cooperative efforts have been undertaken in the areas of renewables, nuclear energy, electric generation, customer systems and the environment.

In the deregulated electric utility industry of the future, which has been envisioned by the National Energy Policy Act of 1992, research and development will continue to be very critical. As the competitive pressures of deregulation increase, the basic structure of the domestic electric industry is redefined and as current electric utilities weather potentially large shifts in their economic positions, the need for federal involvement providing stability and continuity in research and development will be greater than ever.

The Department of Energy, in collaboration with major domestic gas turbine suppliers, has initiated the advanced turbine system program. HL&P has a long history of association with the development of combustion turbine and combined cycle power plant technology that is being addressed by this program. We pioneered the first large commercial combined cycle power plant in 1974.

HL&P is currently participating in the advisory structure of this advanced turbine system program. This program has developed the goal of developing industrial and utility gas turbines with substantially improved performance characteristics, an approximately 15 percent increase in energy efficiency, a substantial reduction in air emissions and a 10 percent reduction in power production costs compared to current gas turbine technology.

This collaborative effort will result in economic and environmental benefits to the citizens of the United States while maintaining domestic energy technology industry ahead of all our international competition.

The effort to maintain leadership in the international energy market is no longer abstract to U.S. electric utilities. HL&P's sister company, Houston Industries Energy, Incorporated, is one of many companies seeking a place in the potentially huge foreign energy markets.

These foreign markets are driven by privatization efforts underway in many countries and the investment in electric supply in many of the developing nations. Competitors for these markets must bring to the negotiating table the ability to utilize the most cost effective and environmentally beneficial technology.

Success in the advanced turbine system program will ensure that U.S. manufacturers remain in a strong position in this highly competitive area.

The Department of Energy can properly assume the role of partner and leader that would be difficult for another entity to undertake. The private partners and advisors in this program are competitors in a very competitive business.

It's unlikely that the pooling of knowledge and financial resources committed to the advanced turbine system project would have occurred without the structure and leadership of a non-competitive entity. Federal involvement in and funding of this program provides needed continuity by helping to dampen the effects of short term business cycle swings upon private research budgets.

It is appropriate to recognize and encourage the achievement of the societal benefits of national interest. These include environmental benefits, reduction in fuel demands with beneficial impact to national energy security, reduced cost to the consumer, including the industrial consumer now competing in the global market, and benefits to the U.S. balance of trade as domestic suppliers remain the suppliers of choice for future electric energy needs.

In conclusion, the government involvement in basic research and demonstration of the technology emerging from basic research is vital to the electric energy business. This involvement helps to diffuse competitive issues, provides program stability, moves technology more rapidly to commercialization and draws down the risk of moving from basic research to commercial products.

We, therefore, support the continued industry partnership with the public by virtue of federal participation in issues related to fossil energy research and development.

And, thank you.

[The prepared statement of Mr. Tees follows:]

TESTIMONY of DAVID G. TEES
before the
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE
ENERGY and ENVIRONMENT SUBCOMMITTEE

Introduction

Mr. Chairman and subcommittee members, my name is David Tees and I am the Vice President of Energy Production at Houston Lighting & Power Company. Thank you for inviting me to testify today. Houston Lighting & Power Company is a regulated, investor owned electric utility supplying electric power to over three million people in the greater Houston area. Houston Lighting & Power Company operates ten electric generating stations with a total capacity of 14,465 MW. Houston Lighting & Power Company utilizes a mix of fuels including Texas lignite, western coal, natural gas, oil, and nuclear. The purpose of my testimony today is to offer a perspective on the value of Department of Energy research in fossil energy. While this perspective reflects the experience of Houston Lighting & Power Company (HL&P), I hope to offer a wider perspective due to my position on various nationwide industrial advisory committees such as Electric Power Research Institute Research Advisory Committee, Edison Electric Institute Generation Subject Area Committee, and the U.S. Industry Team Advisory Committee to the DOE's Advanced Turbine System Program.

DOE Research Programs and Houston Lighting & Power Company

Houston Lighting & Power Company has a long history of involvement in and funding of research and technology development focused on improved service in the electric utility industry. Over the last ten years HL&P has invested over $100 million in research and technology development. In the early 1980's, HL&P and DOE funded and performed research in such areas as geothermal energy development including the installation of a power producing geothermal well, bioprocessing of coal to reduce air contaminants, and joint funding with others of the Fusion Research Center.

HL&P has actively worked to deploy energy conservation technologies using materials developed under DOE's Energy Efficiency and Renewable Energy program. In 1994 Houston Lighting & Power company received a National Award for Energy Efficiency and Renewable Energy for our Commercial Cool Storage Program. This program is a load management effort to shift peak demand associated with commercial cooling to off-peak periods to increase electric generation efficiency.

HL&P has cooperated with the DOE and other electric utilities towards a meaningful electric utility industry response to the issue of global climate change. This effort has resulted in DOE's Climate Challenge Program. The Climate Challenge Program, we believe, is an example of what we hope to be the direction of future environmental programs. It is a program based upon collaborative discussions and understandings between the federal government and the regulated industry. This collaborative energy has led to new and innovative greenhouse gas reduction projects such as a HL&P project which reduces greenhouse gas emissions from rice cultivation. This innovative project, initially funded by HL&P and undertaken by researchers at Rice University, has now received further funding from multiple federal agencies and has expanded to investigations in many rice producing nations, particularly the Phillippines and China. The Climate Challenge Program has lead to commitments from the electric utility industry to reduce greenhouse gas emissions by over forty million metric tons carbon equivalent, a meaningful contribution toward the national target for greenhouse gas reductions. This DOE program has been discussed at international planning meetings held in accordance with the Framework Convention on Climate Change and is used as an example of the benefits and possibilities of partnerships harnessing the power and creativity of public and private sector collaboration.

HL&P has a long history of association with the development of combustion turbine and combine cycle power plant technology, and pioneered the first large commercial combined cycle power plant installation in 1974. HL&P is currently participating in the advisory structure of the DOE`s Advance Turbine System program. This program has the potential to make significant beneficial impacts upon the United States electric industry. I will come back to this program later in my testimony to provide an in-depth discussion of my views of the benefits of federal and private sector collaboration.

HL&P participates in many collaborative research efforts, the primary one being collaborative funding of research programs conducted by the Electric Power Research Institute, or EPRI. The Electric Power Research Institute, with an annual budget of over $500 million, focuses on research and technology issues pertaining to electric generation, transmission, distribution, use, and environmental issues. In late 1994, EPRI and DOE entered into the Sustainable Electric Partnership with the goal of streamlining communications and maximizing collaborative funding potential between the two organizations. To date, cooperative efforts have been undertaken in the areas of renewables, nuclear energy, electric generation, customer systems, and the environment.

In the past, HL&P funded and participated in research and technology development to bring the benefits of these efforts to our community and customers. In the deregulated electric utility industry of the future, as envisioned by the National Energy Policy Act of 1992, research and technology development will continue to play a critical role. As the competitive pressures of deregulation increase, as the basic structure of the domestic electric industry is defined, and as current electric utilities weather potentially large shifts in their economic positions, the need for federal involvement providing stability and continuity in research and technology development may, in fact, be greater than ever.

DOE's Collaborative Advanced Turbine System Program

As I mentioned above, the DOE, in collaboration with major domestic gas turbine suppliers, has initiated the Advanced Turbine System program, or the ATS Program. The ATS Program has established the goal of developing industrial and utility gas turbines with substantially improved performance characteristics: an approximately fifteen percent increase in energy efficiency, a substantial reduction in air emissions, and a ten percent reduction in power generation costs compared to current gas turbine technology. While the DOE is providing substantial funds for this program, the majority of funds for the ATS Program are from private sources.

The technology goals set for this program, when achieved, will be a major breakthrough in energy technology. These breakthroughs will require a major investment; the program budget is over one half billion dollars through the year 2000. This collaborative effort will result in economic benefits to the citizens of the United States and will maintain the domestic energy technology industry at the forefront of international competitors. Additionally, substantial environmental benefits will result from eventual deployment of this technology. The substantial increase in efficiency will also contribute to a world-wide reduction in the emission of greenhouse gas in support of the goals of the international Framework Convention on Climate Change.

The effort to maintain leadership in the international energy market is no longer abstract to U.S. electric utilities. Houston Lighting & Power Company's sister company, Houston Industries Energy, Inc., is one of many companies, both domestic and foreign, seeking a place in the potentially huge foreign energy markets. These foreign markets are driven by privatization efforts underway in many countries and the investment in electric supply and infrastructure in many of the developing nations. Competitors for these markets must bring to the negotiation table the ability to utilize the most efficient, cost effective, and environmentally beneficial technology. Success in the ATS Program will ensure that U.S. manufactures remain in a strong position in this highly competitive arena.

What is the role of government in this process and what is the benefit to the general citizen? The federal government, in this case the DOE, can properly assume the role of partner and leader that would be difficult for another entity to undertake. The private partners in the ATS Program are competitors in a very competitive business. It is unlikely that the pooling of knowledge and financial resources committed to the ATS project would have occurred without the structure and leadership of a non-competitive entity -- the DOE. Federal involvement in and partial funding of this program provides needed continuity by helping to dampen the effects of short term business cycle swings upon the private research budgets. Partial federal funding of this program is appropriate to recognize and encourage the achievement of the potential societal benefits of national interest. These include the environmental benefits I previously mentioned, future reductions in fuel demands with beneficial impact to national energy security, reduced cost to the consumer -- including the industrial consumer now competing in the global market, and benefits to the U.S.

balance of trade as domestic suppliers remain the suppliers of choice for future electric energy needs.

Conclusion

Government involvement in basic research, and demonstration of the technology emerging from basic research, is vital to the electric energy industry. This involvement helps to diffuse competitive issues, provide program stability, move technology more rapidly to commercialization, and draw down the risk of moving from basic research to commercial products. Societal benefits can be achieved in the areas of national energy security, the environment, and balance of trade. We therefore support the continued industry partnership with the public by virtue of federal participation in issues related to fossil energy research and development.

DAVID G. TEES

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EDUCATION

BSME, Texas A&M University, Graduated 1966
Master of Engineering, Texas A&M University, Graduated 1973

CURRENT POSITION

Vice President Energy Production, Houston Lighting & Power Company Responsibilities include all activities regarding fossil plant operations, maintenance, project management, construction management, and corporate environmental activities. 2039 employees in responsible area.

PROFESSIONAL ADVISORY POSITIONS

Electric Power Research Institute, Research Advisory Committee

U.S. Industry Team Advisor, DOE's Advanced Turbine Systems Program

Texas A&M, Mechanical Engineering Department Development & Advisory Council

Edison Electric Institute, Generation Subject Area Committee

Past Member of the Board of Directors and Vice President, Houston Regional Monitoring Corporation

OTHER ACTIVITIES

Trustee of the Galveston Bay Foundation

Chairman ROHRABACHER. Thank you very much, Mr. Tees. And, now we will proceed.

Ms. Godley, you have been giving money to Westinghouse for a five year advanced concepts program in fuel cells. In fact, you mentioned the fuel cells in your testimony.

And, this is the fifth year of that program. And, yet you are asking for another $12.5 million for this next year.

And, as I say, you are proud of this fuel cell program. You mentioned it right up front.

But, the description for this request says this is for market entry, $12.5 million for market entry. Now, Westinghouse—there are other parts to the budget where I have noted, coming through this Committee, that Westinghouse is a recipient of certain federal funds.

And, it just seems to me that Westinghouse is a company with a billion dollars of after-year profits. And, can you explain to us why the taxpayers should be paying for an entry into the market for a company that makes a billion dollars profit a year?

Ms. GODLEY. Certainly. I think the terminology, "market entry," is a tiny bit misleading in this instance.

Fuel cell technologies have not been demonstrated in a utility application in the power generation marketplace. And, this is a utility application of the fuel cell technology that we are cost sharing in an industry partnership in this project.

Included in—in order to prepare a technology or equipment for entry into the marketplace, you have to demonstrate that it will actually work in the application that you are intending it to work in. And, that is what this investment is for, is to take that technology and develop it to a point so that it can be put into an application——

Chairman ROHRABACHER. So, you are taking it——

Ms. GODLEY. (continuing) use and demonstrated for the market.

Chairman ROHRABACHER. (continuing) before potential customers and proving that it can work? Is that what that is?

Ms. GODLEY. Excuse me?

Chairman ROHRABACHER. They are taking this technology before potential customers to prove that it can work; is that what is going on here?

Ms. GODLEY. In a utility application.

Chairman ROHRABACHER. So, you would be taking it over—we are paying Westinghouse to have a demonstration for Mr. Tees; is that right?

Ms. GODLEY. And the marketplace, in general, not just for a single company.

Chairman ROHRABACHER. Right.

Ms. GODLEY. As you know, in the energy business, all of the companies, all utility companies, that are looking for new, cleaner, more efficient technologies look to see what's working in the marketplace.

Chairman ROHRABACHER. So, basically what we've got here is a program that has gone beyond research and development. And, I do understand that when there is basic research and development that can help companies like Westinghouse or any other kind of companies, I understand how that's appropriate.

But, here we've got a situation where the fuel cells have come to a point where we are talking about market promotion.

Ms. GODLEY. That's a misnomer, I think, and truly a mischaracterization. This project, this technology, has not gone beyond research and development.

It is not commercialized or commercializable at this moment technology. In fact, part of the research is making certain that the technology will work and as you try to demonstrate it and develop it for that application what problems are going to come up.

You can't predict that. That's, in fact, part of the research process.

Chairman ROHRABACHER. Okay. Well, let me note that this Chairman has received some flack today for asking a lot of questions of the Department of Energy.

And, what we are asking—what I just asked was based on the fact that what came to us was a request for market entry. This is what came from your request, for $12.5 million, and for a company, as I say, that makes a billion dollars profit after taxes to be the recipient of this.

I just don't think—just so that people will know, it seems to me it doesn't seem to be harassment on the part of this Chairman to want to understand what that means when you, yourself, have said that even that designation isn't really appropriate and needs a little bit more explanation to be understood.

Ms. GODLEY. We are happy to provide that. And, we've also——

[The following information was received for the record:]

Clarification concerning FY 1997 request for $12.5 million for Advanced Concepts:

The requested funding is intended to begin a 50% cost-shared cooperative agreement to conduct R&D which will advance the solid oxide fuel cell technology to a point where the private sector can complete any further improvements required to provide a cost competitive product. The agreement to be negotiated is expected to require four years and approximately $80 million in government funds.

The current cooperative agreement with Westinghouse, which is scheduled for completion in November, 1996, should result in the first submodule (a 100 kilowatt, unpressurized unit containing cells 1.5 meters long) being ready for a field test in a utility setting. The fabrication of this test unit in 1996 and subsequent field test by the private sector in 1997 is expected to determine areas requiring further R&D before the technology can successfully meet user needs. When fully developed, the 100 kilowatt size submodules are expected to form repeating elements of larger modules in the megawatt scale. The largest units operated to date are 25 kilowatt units which contained subscale cells of 0.5 to 1.0 meter in length.

Among the expected R&D needs is the capability for pressurized fuel cell operation in combination with a gas turbine to realize the potential of power generation at up to 70% efficiency. Also expected is R&D on materials and processes which will eliminate several of the expensive laboratory-type fabrication steps currently required; and R&D to obtain the necessary materials lifetimes and low degradation rates which can maintain the high initial system efficiencies. This R&D parallels the experience of the molten carbonate fuel cells.

Chairman ROHRABACHER. Sure.

Ms. GODLEY. (continuing) always been happy to sit down with staff and explain any part of our budget, any part of an entry, so that we can have a full communication.

Chairman ROHRABACHER. Sure.

Ms. GODLEY. And, we will continue to do that.

Chairman ROHRABACHER. Okay. And, you are asking for a 20 percent increase for coal technology export.

And, am I correct that there is no research and development program as part of this, a 28 percent increase for coal technology export? You are not talking about a research program here.

Ms. GODLEY. That's correct.

Chairman ROHRABACHER. So, here we have an industry that has been with us for, you know, several hundred years. Now, it's a mature industry that is a profit-making industry.

Can you explain just why that industry should get $1 million from the taxpayers for basically a promotional incentive or initiative, excuse me?

Ms. GODLEY. A lot of those—and we can, again, provide additional detail, if needed by staff, to understand that budget line entry. But, in many cases, especially with those technologies that the Federal Government has shared the investment in, we have both sent our scientists and folks into promising markets and bring other scientists here to inform them about technology developments in the United States government industry.

Many of the developing countries, in particular, have not moved to a fully market economy. So that their industries and their energy companies are, in fact, government entities. They are not——

Chairman ROHRABACHER. I see.

Ms. GODLEY. (continuing) private sector entities. Having the U.S. government either stand with private sector developers of these technologies or have foreign government or energy business folks coming to this country to see those technologies is an important part of, I think, the——

Chairman ROHRABACHER. So, you are saying that because it's a government, it's better to have a government to government program rather than to have the industry, private companies within that industry, try to do this?

Ms. GODLEY. I don't say government strictly operating on its own. I said standing with industry, private sector industry, in this country to give them additional credibility as seen by some of these other investors, foreign investors.

Chairman ROHRABACHER. Okay. Thank you. We have a vote on now.

And, I will just—would you like to go ahead and do five minutes now?

Mr. ROEMER. I would just say, Mr. Chairman, again thank—I would like to thank this panel for their very, very helpful expert testimony. And, in the fine tradition that you started in the Committee earlier today by yielding some time to other members, I would like to yield my time to Mr. Doyle from Pennsylvania, who is very active and interested in these programs.

Mr. DOYLE. Thank you very much.

Chairman ROHRABACHER. Mr. Doyle, you have four minutes.

Mr. DOYLE. Thank you, Mr. Roemer. I think before I start with Secretary Godley, I would like to ask Mr. De Gennaro some questions.

Could you start basically—I'm curious. What is your background? What are you trained to do?

What is your training in? Are you a scientist?

Mr. DE GENNARO. I am a budget analyst.

Mr. DOYLE. A budget analyst with this group?

Mr. De Gennaro. Yes.

Mr. Doyle. I am trying to understand the common sense in eliminating all federal research and development, as I think I understood your testimony to say that we should eliminate all energy research and development in the country. And, I just wonder if—I mean, it scares me to hear that, because we have been trying in this Committee, within the confines, by the way, of the balanced budget amendment—many of us, including myself, who support a constitutional amendment to balance the budget—to make sure that we also continue to make important investments in this country and to think about the future of this country.

And, you know, when I look at a program like solid oxide fuel cells and all of our competitors all over the world are investing research dollars in this, and you are advocating that we discontinue doing research at the federal level, research and partnering arrangements between the Federal Government and the private sector and academia, research that would not take place in the private sector, given the nature of corporate downsizing and the fact that some of this research just doesn't show dollars in the next quarterly report to the stockholders, research that 10 years from now we are going to be scratching our heads and wondering why we are getting our butts kicked because we didn't make these important investments here within the confines of balancing the federal budget.

And, I wonder if you could just maybe elaborate on where you see this effort coming from if the Federal Government withdraws from all research and development in energy policy?

Mr. De Gennaro. Congressman, I will be brief, because I know you have a vote. It's nice to vote for or pass a balanced budget constitutional amendment, but that just says what we've got to do, which is cut.

And, we think we need to start cutting everywhere, that no part of the budget should be sacrosanct. We would like to see a level playing field in the energy industry and let all the different sources of energy and efficiency compete against each other, all without subsidies.

You and the other folks here today have made a really important point about what good investments all these things are. If they are such good investments, what's wrong with American industry that they are not smart enough to invest in these things?

Mr. Doyle. I will tell you what's wrong with them, sir. They are simply not making these kinds of investments because, as we heard on panels before, that maybe there is a thousand programs and out of the thousand programs we end up with 61 success stories. Not every program is economically feasible.

And, the reality in corporate America today, sir, is that if they can't prove it makes money in the next quarterly report to the stockholders, nobody has the guts to spend the money. That's what is happening in corporate America.

Mr. De Gennaro. Well, then there is something wrong with the——

Mr. Doyle. And, let me say one other thing, too.

Mr. De Gennaro. (continuing) system.

Mr. DOYLE. We are talking about doing these things within the confines of our seven year spending plan, that we spend only 20 percent today of what we spent in 1978 in energy research development in this country. This has been a line item that has been continually coming down.

And, I just think you've picked—you know, while a lot of us support balancing the budget and sticking to a plan that gets us there, and we are talking about sticking to a plan that gets us there in this discussion here, that we don't want to make the mistake of throwing out very valuable investments in the future of this country that are bearing fruit in the long run. Now, we will continue this discussion.

Mr. WAMP. Would the gentleman——

Mr. DOYLE. I will yield to Mr. Wamp.

Mr. ROEMER. I will say to the gentleman from Pennsylvania, before he yields, that I yielded you four minutes——

Mr. DOYLE. I'm sorry. And, I will yield back to you.

Mr. ROEMER. No, no, no. I'm telling you, you keep my four minutes and then you have an additional five that you could yield if you want to yield.

Mr. DE GENNARO. Unfortunately, it's not 1978 anymore.

Chairman ROHRABACHER. Excuse me. We have 10 more minutes before the vote.

Mr. Wamp has a question. And, then if we have time, Mr. Doyle can finish——

Mr. WAMP. Well, Mr. Chairman, thank you for the time. If I could ask Mr. Rackley three questions, one on government subsidies, one on foreign markets and one on—from his testimony about winding down programs.

If it's acceptable to Mr. Rackley, could I submit these for the record and you answer these in writing, these three questions?

Mr. RACKLEY. Certainly.

Mr. WAMP. And, then they will be a part of the record.

Mr. RACKLEY. I would be very pleased to do that.

Chairman ROHRABACHER. Without objection, those questions will be made part of the record and the answers will be made part of the record.

Mr. WAMP. Thank you, Mr. Chairman.

Chairman ROHRABACHER. And, Mr. Doyle, if you have a couple more minutes' worth of questions, we will let you finish the hearing. And, then right after—but let's do it in time to cut and run and vote.

Mr. DOYLE. Okay. I would just say, too, we are in a global economy right now, sir.

And, how are we asking American companies to compete against foreign companies whose governments are subsidizing a lot of these programs? Yet, you are asking us to withdraw these efforts from our American companies.

How is that a level playing field for American companies when their foreign competitors are being subsidized and you are asking us to withdraw the partnership arrangement, not subsidies but a partnering arrangement, we have right now?

Mr. DE GENNARO. Well, the partnership arrangement involves a subsidy. The government gives money to the company. That's a subsidy, right?

Mr. DOYLE. No. Maybe we should talk about this a little further.

When we talk about partnering arrangements, we are talking about the private sector putting up substantial dollars along with the Federal Government and academia. These are arrangements put together which would not happen without the Federal Government also contributing to them.

They wouldn't be—they could never get them past the Board of Directors in a lot of these corporate offices to spend this money if there wasn't some sort of cost sharing arrangement. So, it's not merely the Federal Government sending a check down to a company.

And, the other thing is, sir, there is a tremendous benefit that comes back to the taxpayer.

Mr. DE GENNARO. That's the key thing. If these investments make sense, then why isn't the private sector doing them?

Why do we have billion dollar companies who need money from—I mean, I would ask you, what are the assets of——

Mr. DOYLE. Mr. De Gennaro, the reality is that some of these technologies we are talking about are for a cleaner environment. And, if you are talking about Green Scissors, I mean, part of what we are talking about for a cleaner environment, some corporations simply aren't going to spend the money for technology that just makes the air cleaner but doesn't make any money for their shareholders.

Mr. DE GENNARO. We are the scissors part of the Green Scissors. We are not the green part of the Green Scissors.

Mr. DOYLE. Oh, I see. Okay. Thank you very much.

Chairman ROHRABACHER. Mr. Doyle, do you have something to wrap it up with?

Mr. DOYLE. Well, let's go down and vote. And, we are—are we going to come back or are we going to finish?

Chairman ROHRABACHER. Well, if you can finish it now, we are not going to have to bring these folks back.

Mr. DOYLE. I could talk to this gentleman for an hour.

[Laughter.]

Chairman ROHRABACHER. There is an Irish pub down the street that I would——

[Laughter.]

Mr. DOYLE. No. You know, I think that it's clear that we need to continue to make these investments within the parameters of balancing our budget.

Thank you, Mr. Chairman.

Chairman ROHRABACHER. Okay. Thank you very much, Mr. Doyle.

We have got Mrs. Cubin who——

Mr. DOYLE. Perhaps Ms. Godley would take at least one minute to respond.

Chairman ROHRABACHER. We are going to give her one minute to sum it all up.

Mr. DOYLE. Thank you.

Chairman ROHRABACHER. Mrs. Cubin from Wyoming will be submitting some questions for the record.

Ms. GODLEY. Certainly.

Chairman ROHRABACHER. And, as has been the tradition of this Committee, we have time for the representative from the Administration, because usually you are the one under attack, to have a few last moments to express—to sum your side up?

Ms. GODLEY. Sure, I would. Going back to the issue of corporate welfare one last time, I think that, just to give two examples to Mr. De Gennaro that might be helpful to him and maybe expand on what Congressman Doyle was saying, let's look just for a second at the electric power industry.

The Federal Government and state governments are changing the regulatory playing field that this industry is required to compete in. We have changed the rules of competition in that industry in very short order.

That creates—government action is creating uncertainty in those marketplaces that makes these companies who owe a duty to their shareholders to bring a profit in to be willing and able to invest in long term, high risk research and development activities that will be needed to offset the carbon and the other environmental impacts of increased use of coal and other fossil fuels in energy production in this country. It's an appropriate federal role to invest with those companies—not to hand them money but to work with them in a partnership—to make sure that we have the technologies needed to have a clean environment at a time when we have created incredible uncertainty in the industry.

To go specifically to Mr. De Gennaro's remarks about the majors who are partners in our oil program, the program that he is referring to has seven majors in it, 29 independent producers, 24 academics, eight state agencies and 34 service companies. And, in that program alone, one of our successful projects raised enough money in federal royalties to pay for the entire program.

That was a sound investment in taxpayer dollars. And, that, I think, is what's called stewardship of the federal taxpayer dollars and a benefit to the public.

Chairman ROHRABACHER. Thank you, Ms. Godley. And, we appreciate you and the other panelists.

Let me just say that there is an honest disagreement in philosophy among different people as to the role of government. Some people think that government screws things up when it gets involved in it; and, other people think that it can really help things along.

And, that is an honest, philosophical difference. And, we want to have both sides presented at these hearings.

Thank you very much. This hearing is adjourned.

[Whereupon, the hearing is adjourned 3:57 p.m., Wednesday, April 17, 1996.]

[The following material was received for the record:]

APPENDIX 1—

Additional Statements For The Record

Testimony of Paul C. Liepe, Ph.D.
Executive Director, Geothermal Heat Pump Consortium

for the

Subcommittee on Energy and Environment
Science Committee
U.S. House of Representatives

U.S. Department of Energy FY 1997 Budget Request
April 17, 1996

My name is Paul C. Liepe, Ph.D., and I am Executive Director of the Geothermal Heat Pump Consortium (GHPC). GHPC is a non-profit corporation comprising more than 240 electric utilities serving about half the electric meters in the United States, nearly 250 equipment manufacturers, allies and associations, the U.S. Department of Energy, the U.S. Environmental Protection Agency, the Federal Energy Management Program (FEMP), the National Rural Electric Cooperative Association (NRECA), the Electric Power Research Institute (EPRI), the Consortium for Energy Efficiency (CEE), the International Ground Heat Source Pump Association (IGSHPA), the Edison Electric Institute (EEI), the Air Conditioning Contractors Association (ACCA), the National Groundwater Association (NGWA), the Air Conditioning and Refrigeration Institute (ARI), and the American Public Power Association (APPA). We represent a broad and unprecedented partnership to develop and disseminate the economic and environmental benefits of the most efficient and effective heating, cooling, and water heating system available -- the Geothermal Heat Pump.

GEOTHERMAL HEAT PUMPS: A UNIQUE RENEWABLE TECHNOLOGY

Geothermal Heat Pumps (GHPs) are a renewable technology that use the Earth as a renewable source and sink for energy to heat and cool buildings, and to heat water. They do this through the use of direct connections to the ground or surface waters -- usually closed water/antifreeze loops that transfer heat back and forth between the ground and a building without depleting or affecting groundwater resources. The loops are simply polyethylene or polybutylene pipes, which are laid out in shallow vertical wells, horizontal trenches, or in ponds. Geothermal can operate in almost all climates and soils -- tapping a resource that's literally right under our feet in our own backyards and parking lots.

One of our member manufacturers estimates total North American installations of geothermal heat pumps to number over 200,000 to date, with ground loops now providing the equivalent of at least four trillion BTUs of clean, renewable energy to heat and cool homes and businesses every year. While most of the installations of geothermal systems have been in homes, we have identified over 80 unique uses of GHPs in commercial applications, bringing economic benefits to businesses ranging from alligator farms, to hotels and resorts, to large and small office buildings, to restaurants and convenience stores. In addition, geothermal is helping over 200 schools -- ranging from elementary schools to public colleges -- reduce their economic burden on taxpayers.

Thus, even though the technology has not nearly been fully utilized, it has been well established on a technical basis that geothermal heat pumps simultaneously offer benefits to consumers, local and national economies, utilities, and society at large.

Benefits to Consumers

For consumers, geothermal systems offer:

Lower annual operating costs through the use of renewable energy. In almost all cases, consumers using geothermal systems will see their energy bills cut by 45% or better by substituting free, renewable energy for fossil fuels. Most GHP systems also offer an opportunity to heat water, providing additional operating cost savings. Typically, geothermal home owners experience annual heating and cooling costs in the range of $240-$550 per year -- that translates to about $.67 to $1.50 per day for single-family homes. Once considered an upscale item for the relatively well-off, geothermal systems are increasingly finding their way into affordable housing -- they expand the idea of "affordable" housing to mean not just easier to buy initially, but also easier to afford on a monthly basis. Similarly, in the commercial sector, geothermal increases commercial profits by reducing overhead associated with heating, cooling and water heating.

No outdoor unit. Since the GHP's connection to the ground is buried and completely invisible, there is not outdoor equipment to create noise or clash with landscaping and architecture. This increases aesthetics, and decreases opportunities for tampering and vandalism. Additionally, there is no leakage over time of ozone-destroying HCFCs, as in typical outdoor equipment.

Higher reliability and longer life. Since all their operating equipment is usually indoors and works without combustion, geothermal systems do not experience weathering or fouling from burning fuel. Thus, they can be expected to work better over time with less maintenance, and last longer than conventional heating and cooling equipment. Geothermal systems are produced by most of the nation's leading heat pump manufacturers with many of the same components that conventional equipment use.

Comfort. Geothermal systems also provide a very high comfort level, including humidity control. This is a central reason why in survey after survey over 95% of geothermal owners say they would recommend the system to a family member or friend. In commercial facilities, geothermal systems allow for localized control

Economic Benefits

GHPs benefit both local economies and the national economy in several ways:

Increased local value-added and employment. Since GHPs require ground coupling, their installation is inherently more labor-intensive. Their installation creates economic opportunities for drilling and excavating companies, which are generally localized, small- to medium-sized businesses. In fact, the primary reason why the National Ground Water Association is a partner in GHPC's National Earth Comfort Program is due to the potential for more than doubling the demand for vertical boreholes nationally. This will create thousands of additional jobs in the drilling and excavating industries -- we estimate in the order of 3,000 to 4,500.

Increase demand for drilling and excavating equipment. A spin-off effect of developing GHP technology is that the demand for drill rigs, backhoes and other ground loop installation equipment will be increased. Since well over 90% of such capital utilized by the geothermal HVAC industry is domestically produced, developing GHP technology will have important spin-off benefits for the domestic manufacturers of such equipment.

Improved trade balance. Development of GHPs will improve national trade balance in at least two ways. First of all, it will decrease demand for foreign oil, as consumers shift away from oil heating to geothermal (many of them do not receive natural gas service, and geothermal will be one of few viable replacement options for them. Similarly, at the electric utility level, geothermal heat pumps reduce peak demand, based on their super-efficient use of electricity. Therefore, electric utilities that develop GHP technology in their service territories will have less need to utilize peak generating plants, which often run on imported natural gas and oil.

In addition, U.S. GHP manufacturers are worldwide leaders in terms of production levels, equipment performance, quality and reliability. As efforts to develop GHP technology proceed in the U.S., there will be important technology transfer opportunities arising, particularly in Canada and Europe. This will lead to greater export opportunities for U.S. equipment manufacturers.

Increased national competitiveness. As businesses and public agencies turn to GHPs to save money, they will help improve national competitiveness. Private sector businesses will reduce their overhead and become more competitive in international markets. Public sector institutions will lower their operating costs as well, thereby reducing their burden on taxpayers. In fact, GHPC is working very closely now with FEMP, and will be targeting efforts under this proposed funding to continue demonstrating GHPs at DOD facilities, building on positive experiences in the recent past. We also anticipate other Federal agencies to begin taking greater advantage of GHPs in the next few years as a result of our efforts, in order to comply with Congressional and Executive mandates to drastically reduce their fossil energy usage by 2005. This will assist Congress in its ongoing efforts to reduce the Federal deficit.

Benefits to Utilities

GHPs offer electric utilities increased customer satisfaction and business stability. Once the ground loop is installed, it is likely that a customer will continue to use it indefinitely, creating a satisfied customer willing to purchase service from the electric utility for an extended time. GHPs offer a flatter load profile, reducing the need for electric system construction while more efficiently utilizing existing facilities, and thus potentially lowering the cost of electricity sold. These benefits of GHPs -- improved customer energy services and the potential for lower rates -- are the main reasons why GHPC has already attracted the participation of electric utilities representing half of the electric meters in the nation.

Benefits to Society

According to an EPA report, *Space Conditioning : The Next Frontier*, GHPs rank in the uppermost range of equipment efficiency offerings. Under the regional electric utility generating fuel mix projected for 2000, GHPs will have lower carbon dioxide emissions than all other equipment.

GHP systems typically require lesser quantities of refrigerant (usually HCFC-22) than standard air conditioners. GHP systems are typically sealed at the factory, and do not require field installation of pressurized refrigerant lines. The result is reduced leakage of refrigerants to the atmosphere.

Unlike some other types of heating and cooling systems, GHPs are pollution free at the point of use. The modest amount of emissions that do occur are at the electric power plant, where emissions are vigorously controlled and monitored.

An additional benefit of this technology can be better controls on the emission of ozone forming compounds. GHPs can offer a means to reduce ozone formation while actually reducing customer energy costs and increasing customer convenience and comfort.

In addition, GHPs can be instrumental in achieving space heating and cooling market transformation. As GHPs increase in both efficiency and market penetration, the overall efficiency of the space conditioning market improves. GHPs can help create a new competitive standard for space conditioning, providing strong encouragement for efficiency improvement in all other types of space conditioning equipment.

GHPC'S HIGHLY LEVERAGED PARTNERSHIP

GHPC is a unique partnership. It is a collaborative effort between the U.S. Department of Energy, the U.S. Environmental Protection Agency, and a broad range of private sector organizations. Yet it is highly focused in its mission, which is to rapidly develop a promising technology so that the nation can benefit from it as quickly as possible, without a great deal of public expenditure. In fact, the $35 million that DOE will contribute will be immediately leveraged by at least $65 million in private industry (mostly utility) investments; together, these combined technology development efforts will result in $9 billion of further investments in GHPs by private and public end-users. The partnership is also unique in that, instead of wielding a heavy hand, government is allowing market forces and players implement efforts on a grassroots level, based on the needs of their own regional and local markets. Rather than command and control, the Federal government is providing leadership, assistance in reducing the risk to expanding investments to develop this technology, and mechanisms to quickly transfer success from one set of market players to another.

Staying on Target: Critical Need for Continuing Support

In its first full year of operation, GHPC has already achieve several important accomplishments, prompting many positive comparisons to other existing industry consortia. GHPC completed several key studies benchmarking current utility geothermal programs, geothermal design tools, training facilities, and market conditions. Based on this knowledge, GHPC immediately launched several projects to enhance training programs, design tools, technical knowledge of soils, grouts and pumping equipment, field assessments of a new, lower-cost loop technology, and compilation of case studies on use of geothermal. Just as importantly, GHPC has helped many of its member utilities design programs for developing the technology in local markets in very new and innovative ways.

These efforts will provide models for energy service programs that can be delivered effectively and at lower cost to utility ratepayers. In addition, GHPC utilities are increasingly partnering with public-sector organizations, such as school boards. Virginia Power is developing a statewide partnership with the Commonwealth of Virginia for geothermal technology demonstrations in state facilities. Kansas City Power & Light is partnering with the City of Kansas City, MO on urban revitalization projects featuring energy-efficient homes with GHPs. Another GHPC member utility is working with a local city to improve conditions at publicly-assisted housing projects through renovations featuring geothermal systems.

These efforts are extremely timely for two reasons. Utilities need assistance in developing energy conservation and energy services programs for consumers at the same time that they transition into a more competitive environment. Thus, GHPC's efforts will have important ramifications beyond simply developing geothermal technology -- they can have more generalized impact on how utilities look at energy services in a competitive environment.

Secondly, to the extent that GHPC's members can work with public entities to revitalize communities or reduce the cost of operating public agencies and programs, we as a nation of taxpayers all benefit.

Despite such a strong start for the National Earth Comfort Program, GHPC needs continued support from Congress to stay on track. The NECP was premised on a $35 million contribution from DOE -- this was a key element in our early success in attracting utility participation. The utilities who have joined GHPC have committed to a six-year program, based on that understanding, and have responded strongly to opportunities to work together on technology development projects. Yet we have just started to attack the many market barriers to GHPs. We still have much to do from the standpoint of rationalizing the production and installation process, reducing first cost, developing market infrastructure (in many areas, there are inadequate numbers of geothermal dealers and installers), improving design tools, and increasing awareness about the benefits of the technology among home and business owners, contractors, builders, architects, engineers, and public agency administrators.

While the National Earth Comfort Program is designed to address these issues, and has started doing so, DOE's contribution to GHPC during Fiscal Year 1995 was cut back by over 20% due to recision legislation, and its FY 1996 budget was $5.3 million compared to the $9 million laid out in the original plan for NECP. In order to continue expanding utility enthusiasm and support for the program, and to stay on task toward program completion (and phase-out of GHPC) by early next decade, **we respectfully request restoration of funding for DOE's geothermal heat pump efforts during FY 1997 to the $8.5 million budget originally laid out in the NECP plan.** Without continuing strong DOE focus and leadership, we fear a serious erosion in private sector collaboration around this valuable technology development effort, given the upheaval and competitive tensions that are arising in the industry. Continuing short-term Federal investment in this high-value, high-leverage program at the present time will be key in helping the nation achieve environmental and economic objectives without the need for costly and contentious environmental and energy efficiency regulations.

We trust our testimony has been of value to the Subcommittee, and would be pleased to provide any further information that you may require.

No Federal funds were used in the preparation or presentation of this testimony.

GEOTHERMAL HEAT PUMP CONSORTIUM

UTILITY MEMBERS	STATES
Allegheny Power System	
Monongahela Power Co.	OH, WV
Potomac Edison Co.	MD, VA, WV
West Penn Power Co.	PA
American Electric Power	
Appalachian Power Co.	VA, WV
Columbus Southern Power Co.	OH
Indiana Michigan Power Co.	IN, MI
Kentucky Power Co.	KY
Kingsport Power Co.	TN
Ohio Power Co.	OH
Wheeling Power Co.	WV
Atlantic Electric	NJ
Baltimore Gas & Electric	MD
Black Hills Power & Light Co.	MT, SD, WY
Bonneville Power Administration	OR
(representing 120 public utilities)	OR, ID, WA, CA, MT,WY
Carolina Power & Light Co.	NC, SC
Centerior Energy Corporation	
Cleveland Electric Illuminating	OH
The Toledo Edison Company	OH
Central & South West	
Central Power & Light Co.	TX
Public Service Co. of Oklahoma	OK
Southwestern Electric Power Co.	AR, LA, TX
West Texas Utilities Co.	TX
Central Hudson Gas & Electric	NY
Choctawhatchee Electric Cooperative	FL
Consumers Power Co.	MI
Delmarva Power	DE, MD, VA
Detroit Edison	MI
Duke Power	NC, SC
East Kentucky Power Corporation	
Big Sandy RECC	KY
Blue Grass RECC	KY
Clark RECC	KY
Fox Creek RECC	KY
Inter-County RECC	KY
Jackson County RECC	KY
Licking Valley RECC	KY
Nolin RECC	KY

Salt River RECC	KY
Shelby RECC	KY
General Public Utilities	
Jersey Central Power & Light Co.	NJ
Metropolitan Edison Co.	PA
Pennsylvania Electric Cop.	PA, NY
IES Utilities	IA
Interstate Power	IA, IL, MN
Jackson County REMC	IN
Kansas City Power & Light Co.	KS, MO
Kentucky Utilities Company	KY, TN, VA
Minnesota Power	MN
New England Electric System	
Granite State Electric Co.	NH
Massachusetts Electric Co.	MA
Narragansett Electric Co.	RI
New England Power Co.	MA
New York State Electric & Gas	NY
Niagara Mohawk	NY
Northeast Utilities	
Connecticut Light & Power Co.	CT
Holyoke Water Power Co.	MA
Public Service of New Hampshire	NH
Western Massachusetts Electric	MA
Northwest Rural Public Power District	NE
Oceana Electric Cooperative	MI
Oglethorpe Power Corporation	GA
Altamaha EMC	GA
Amicalola EMC	GA
Canoochee EMC	GA
Carroll EMC	GA
Central Georgia EMC	GA
Coastal EMC	GA
Cobb EMC	GA
Colquitt EMC	GA
Coweta-Fayette EMC	GA
Excelsior EMC	GA
Flint EMC	GA
Grady EMC	GA
GreyStone Power Corp.	GA
Habersham EMC	GA
Hart EMC	GA
Irwin EMC	GA
Jackson EMC	GA
Jefferson EMC	GA
Lamar EMC	GA

Little Ocmulgee EMC	GA
Middle Georgia EMC	GA
Mitchell EMC	GA
Ocmulgee EMC	GA
Oconee EMC	GA
Okefenoke Rural EMC	GA
Pataula EMC	GA
Planters EMC	GA
Rayle EMC	GA
Satilla Rural EMC	GA
Sawnee EMC	GA
Slash Pine EMC	GA
Snapping Shoals EMC	GA
Sumter EMC	GA
Three Notch EMC	GA
Tri-County EMC	GA
Troup EMC	GA
Upson County EMC	GA
Walton EMC	GA
Washington EMC	GA
Ohio Edison	OH, PA
Otter Tail Power Co.	MN, ND, SD
Pacific Gas & Electric	CA
PECO Energy	PA
Pennsylvania Power & Light Co.	PA
Plumas-Sierra Rural Electric Cooperative	CA
Potomac Electric Power Co.	DC, MD
PSI Energy	IN
Southern California Edison	CA
Southern Company	
Alabama Power Co.	AL
Georgia Power Co.	GA
Gulf Power Co.	FL
Mississippi Power Co.	MS
Savannah Electric & Power Co.	GA
St. Joseph Light & Power	MO
Tampa Electric	FL
Tennessee Valley Authority	TN
Truckee Donner Public Utility District	CA
TU Electric Co.	TX
Union Electric	IA, IL, MO
Virginia Power	NC, VA

NATIONAL ORGANIZATIONS

Air Conditioning Contractors of America
American Hydrological Society
American Public Power Association
Association of Energy Engineers
Association of Energy Engineers, Capital Chapter
Edison Electric Institute
Electric Power Research Institute
International Ground Source Heat Pump Association
National Ground Water Association
National Food and Energy Council
National Rural Electric Cooperative Association

GEOTHERMAL HEAT PUMP MANUFACTURERS

Addison Products Company	FL
Aqua Cal	FL
Carrier Corporation	OK, NY
Climate Master	OK
Econar Energy Systems Corporation	MN
Envirotherm	NY, TN
FHP Manufacturing	FL
Geo Thermal Plus, Inc.	KY
Hydro Delta Corporation	MO, PA
Hydro-Temp Corporation	AK
Mammoth, Inc.	MN
McQuay International	NY
Millbrook Industries-Hydronic Division	SD
Thermal Energy Systems, Inc.	PA
Thermal Energy Transfer Corporation	OH
The Trane Company	CO, GA, TX, WI
WaterFurnace International	IN

OTHER MANUFACTURERS AND TRADE ALLIES	FACILITIES
AAA Enterprises	GA
A&A Air Services	DE
Action Mechanical Services, Inc.	
ADI Technology Corporation	VA
ADM Associates, Inc.	CA, MD
Advanced Heating Technology, Inc.	DE
AES Consulting	OK
Air Systems Plus	CA
Alderson Engineering, Inc.	

Alternate Energy Sources, Inc.	
Alternative Energy Corporation	NC
American Geothermal, Inc.	TN
American Hydrogen Association	AZ
Apogee Interactive, Inc.	GA
Architect	PA
Architron	MN
Armstrong Pumps Inc.	NY
Joseph V. Arno	MA
Atlantic Coastal Drilling	
Automated Test Labs,Inc.	VA
Ball Drilling Company	TX
Michael Barlow Well Drilling Svc., Inc.	MD
B.B. Brown Company	MI
The Bell Company	DC
Beltsville Heating & Air Conditioning, Inc.	MD
Berg's Heating and Air Conditioning, Inc.	GA
BMS & Life Enhancement Industries	TX
Harry J. Braud Consulting	LA
Brinkerhoff Environmental Services, Inc.	NJ
Browning-Ferris Industries	TX
Btu Technology	MD
Burtner Geo Systems	PA
California Energy Commission	CA
Catalyst Financial Group	CT, VT
CDH Energy Corporation	NY
Center for Sustainable Building & Technology	MA
The Charles Machine Works, Inc.	OK
Charter Plastics, Inc.	PA
Comfort Supply, Inc.	PA
Concord Engineering Group, Inc.	NJ
Conservation Products International	FL
Creative Engineering Associates	
Danco Enterprises, Inc.	OH
DeMarco Energy Systems ofAmerica, Inc.	TX
Desmear, Inc.	NC
Diamond Drilling Co., Inc.	NJ
Dominion Water, Inc.	VA
Dufford Drilling Co.	CT
EAM Associates, Inc.	NJ
Earth Energy Engineering, Inc.	VA
Earth Energy Loop Systems	MI
Earth Energy Technology & Supply	OK
ECR Technologies, Inc.	FL
Eichelbergers, Inc.	PA
Endot Industries	NJ

Energy Capitol Partners	MA
Energy Center of Wisconsin	WI
Energy Directions	MN
Energy Performance Services	PA
Energy Research Group, Inc.	MA
Enlink Geothermal Services	
Enviro-Management & Research, Inc.	VA
Environmental Control Specialists Corp.	MO
Environmental Financial Services	VA
Environmental Strategy, Support & Solutions	VA
Enviro-Tec, Inc.	IA
Evangelist Service Co.	NV
Falleur Heat & Air	
F.B. Crouse Supply, Inc.	MI
Charles R. Foster III	VA
GDS Associates, Inc.	GA
Geo-Air Heating and Cooling, Inc.	TX
Geo-Air, Inc.	NJ
Geocorp	TX
Geo Engineering & Testing Corporation	OK
Geo-Flo Products Corporation	IN
Geofurnace Systems, Inc.	MI
Geo-Heat Center	OR
Geomatrix, Inc.	MD
GEOMET Technologies, Inc.	MD
Georgia Geothermal, Inc.	GA
GeoSource Worldwide, Inc.	GA
GeoTech	IN
Geothermal/Air Conditioning Training	FL
Geothermal Dynamics Northwest	OR
Geothermal Energy Association	CA
Geothermal Energy Management	GA
Geothermal Management Company, Inc.	CO
Geothermal Marketing Services	IN
Geothermal Services, Inc.	NJ
Geothermal Surverys, Inc.	CA
Geothermal Technologies, Inc.	OH
Gilbert and Associates	GA
Gipson Well Co.	AR
Goshorn, Inc.	VA
Grace Geothermal, Inc.	OH
Granger Heating & Cooling	OH
Ground Loop Heating & Air Conditioning	
Ground-Source Heating & Cooling	OH
Harrell and Associates	PA
Heatac Energy Group	CA, LA, NJ, NY, PA

Hudson Extrusions, Inc.	OH
Hydro Dynamic Engineering	CT
Hydro Pump Company	NE
ICRC Energy, Inc	VA
Idaho Water & Energy Research Institute	ID
Ingersoll-Rand Company	VA
International Geothermal, Inc.	TN
Jantzen Engineers	IL
Jensen Well Company	NE
John Geyer & Associates, Inc.	WA
JPI, Inc.	TX
K.W. Lambert Construction	VA
Edward A. Kush, Jr.	NY
Laing Thermotech, Inc.	CA
Landsberg Engineering, PC	NY
Lanna, Dunlap & Spriggs, PC	
Logan Capital Company	CA
Loop Tech International	TX
Lord and Company, Inc.	VA
LSB Industries	OK
Luce, Schwab & Kase, Inc.	NJ
John F. Malloy, Jr.	OH
MBH Associates	CA
Steve McCarley & Associates	TX
Mechanical Equipment Sales,Inc.	VA
Mechanical Systems	NV
Merrill Manufacturing Co.	IA
Metering Engineering, Inc.	SC
Michigan Geothermal Energy Association	MI
Middleton Corporation	OH
Mill Pond, Inc.	NJ
Miller Mechanical Contractors, Inc.	PA
Miller and Sons Heating	PA
MMG Meuwissen Marketing Group	
Montana Bureau of Mines and Geology	MT
Montgomery Heating & Cooling Co.	MI
National Guard Bureau	VA
Neos Corporation	CA
New Jersey Heat Pump Council	NJ
New York State Energy Research & Development Authority	NY
Newton Enterprises	NY
North Georgia Mechanical	GA
Nowacki Stone	IN
Nth Power Technologies	CA
Ohio Geothermal Services	OH
Parratt-Wolff, Inc.	NY

Pearson Mechanical, Inc.	TX
PEC International	CA
Pender Water Wells	TX
Peterson Heating and Cooling, Inc.	MI
Phillips Driscopipe	CA, KY, OK, PA, SC, TX
Pinckley Engineering, Inc.	KY
Policy Research Associates	VA
Potomac Environmental &Power Tech	MD
Edward Powell Pump & Well Drilling	PA
Prime Mechanical	GA
Process Improvement Engineering	OH
REEP Incorporated	NJ
Renewable Energy Alternatives	OR
Royal Contractors	NY
Ryan Service Company	OK
SAIC/The Fleming Group	NY
Sandia National Laboratories	NM
Schall Sales Associates, Inc.	
SFMC	
Shannahan Artisian Well Co., Inc.	MD
Shore Water Refining	DE
Allan Skouby	TX
G. Kyle Smith	TX
Soil Consultants	VA
Somerset Well Drilling Company, Inc.	MD
Southern Comfort	
Southern Heating & Air Conditioning, Inc.	TN
Juilan Speer Co.	
Stratz Heating & Cooling	MI
Subterra Ground Source Division of SH&F, Inc.	OR
Sunteq Ltd.	PA
Syracuse Energy	NY
Technology Prospects, Inc.	VA
Thermal Loop Corp.	MD
Today Associates	NY
Total Air and Heat Company	TX
Tsa La Gi, Inc.	ND
Turbotec Products, Inc.	FL
TVI	AL
Unified Corporation	VA
United Automatic Heating Supply	OH
U.S. Army HQ National Training Center	CA
U.S. Army Pacific	HI
U.S. Navy Geothermal Program Office	CA
Vanguard Plastics	KS, SC
Virginia Energy Services	VA

Virginia Service Company	VA
Walkerville Area Fire & Rescue	MI
Washington State Energy Office	WA
Water and Energy Systems Corporation	ME
Water Resources, Inc.	NY
Weber's Well Drilling	DE
WEDGCO Engineering	MD
Wilmington Housing Authority	DE
Windy City Sales, Ltd.	IL
Winslow Pump & Well Inc.	MD
Wm. Nesbit and Associates	CA
ZiegCo	NJ

UNIVERSITIES

Belmont Technical College	OH
Central Texas College	TX
Ferris State University	MI
Hocking College	OH
Northeast Iowa Community College	IA
Richard Stockton College of New Jersey	NJ
University of Alabama	AL
University of Idaho	ID
University of Wisconsin Madison	WI
Western Iowa Tech Community College	IA

STATEMENT OF DAVID M. PELLISH

Program Manager, now retired, of the Department of Energy Metal Casting Competitiveness Research Program (1990-1994)

In response to Congressional directions and the enactment of Public Law 101-425, the "Department of Energy Metal Casting Competitiveness Act of 1990", I was selected by DOE as the Designated Federal Official responsible for managing the execution of that program. I organized the program's Industrial Advisory Board in accordance with the Congressional mandate and served as its Executive Secretary. Annual Reports to the Congress drafted by my office were transmitted each year thereafter.

Apparently, our activities and accomplishments were noticed by others, because I was invited to describe my ideas in early 1933 to officials at the White House Office of Science and Technology Policy. Not long after that meeting, I was requested to organize an inter-agency committee of metal casting, reporting to the OSTP, through the National Institute of Science and Technology.

I retired at the end of September, 1994, after twenty-five years of federal service. During that time, I served as Assistant Director of the National Commission on Urban Problems, a presidential commission mandated by the Congress in the latter years of the 1960's. Among my recommendations, endorsed unanimously by that commission, was the establishment of the National Institute Building Sciences as a non-governmental agency designed to enhance the technological advancement of the nation's buildings. After receiving Congress bi-partisan support of that concept and President Ford's approval in 1974, that institution has been in the forefront of major technical issues confronting buildings since then. The insight I gained in those years helped me better understand the issues confronting the metal casting industry.

Having briefly described my credentials and experiences, I would like to offer some suggestions designed to enhance the effectiveness of funds which this Sub-Committee will decide is most appropriate at this time. I take for granted that there will be a continuation of funds for this program because the competitiveness of the metal casting industry is critical to the continued growth of the many American industries that it supplies. Because this particular industry is largely composed of small businesses, the sector that has accounted for the largest growth in jobs, it is vital that government support of its technological advancement be continued.

1. In my opinion, it is important that this Sub-Commitee add sufficient directions in the appropriation's language to assure that the funds will be used for the metal industry's top priorities in this critical period.

2. Precise determination of those priorities should be made after full public meetings are conducted by the program's Industrial Advisory Board in areas of the country where the small- and medium-sized companies are concentrated. Directions regarding membership on that advisory body should be modified to assure that it will truly represent all sectors of this diverse industry, and all sizes of companies, especially those that do not belong to any trade association. A very substantial portion of the industry does not belong to any society. Their vital needs must, in my opinion, be given full consideration in the use of the taxpayers money.

3. I respectfully submit my strong opposition to a reported plan to establish an executive committee for managing this program, which would consist of one DOE employee and several

staff members of trade associations. During my tenure in this program, owners and executives of many small- and medium-sized companies vehemently opposed the agendas of those trade association staff members. The outlook of these staff people was simply inconsistent and insensitive to the urgent needs of the smaller companies. I fear that the very laudable intentions of Congress, in calling for the establishment of the Advisory Board, will be severely undermined by this proposed new ad-hoc DOE management group.

4. Unless there is clear language focusing on the dissemination of technical information arising from this program to the entire industry at the state and local level, it is possible that the those technological advancements may never be made available to the smaller companies through channels convenient and affordable to them. Many states and localities have taken the initiative to establish extension centers designed to serve this purpose for the manufacturing industries. I urge the Sub-Committee to add language that would make it mandatory for this program to provide assistance in facilitating the work of such centers. The Metal Casting Center at the University of Northern Iowa has successfully demonstrated the benefits of such technology transfer activities at the state and local level. The DOE Metal Casting Program can learn much from that Mid-West institution.

5. Finally, greater attention should be given to improving Federal inter-agency collaboration and joint funding in support of projects aimed at enhancing this industry's technological advancement. Lack of proper coordination is wasteful of the limited resources presently available. In addition, there should be no favoring of companies or institutions merely because they are skilled in grantsmanship...at a time when the government can ill afford to subsidize the more affluent companies and institutions that could conduct R&D with their own funds.

Additional Question for Assistant Secretary Ervine:

If there is a reduction in funds, please explain how DOE will continue to support the promising research in electrochromic films for windows. Will the available funds be applied to continuing the work at Tufts University, which has won world-wide recognition for its trail-blazing contributions? If not, does DOE plan to continue to support research in this field at a a national laboratory? What is DOE's justification for discontinuing the original inventor's work in favor of subsidizing secondary research?

Testimony delivered before the
HOUSE SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
April 17, 1996
by Dean M. Peters
Editor, FOUNDRY Management & Technology
Co-Chairman, DOE Metal Casting Industrial Advisory Board

Mr. Chairman and Subcommitteee Members:

I would like to thank you for inviting me to testify here today, and on behalf of U.S. metalcasters, may I also express my thanks to the Congress for their support of our industry through the passage of Public Law 101-425, entitled the *Department of Energy Metal Casting Competitiveness Research Act of 1990.* I come to you today as co-chairman of the Industrial Advisory Board established by this Act to urge your continued support for the partnership this program has nurtured.

Our industry welcomes the scrutiny that Congress and the federal government applies to research programs that use resources from the public sector. We are confident that, when reviewed on its merits, the metal casting research program will stand up to the strictest criteria. It was authorized with bipartisan Congressional support; requires equal matching funds from private enterprise; involves a rigorous competitive process and peer review; benefits our nation's economy; and it assists small business.

The process of melting metal and pouring it into a mold is 6,000 years old. Every culture that ever reached the status we call "civilization" did so largely because it could cast and work in metal. From the Bronze Age forward, advances in metalcasting led culture after culture to its days of glory and triumph. It is no less so for the United States, whose traditions in metalcasting date back 350 years to Saugus, Massachussetts. Years before the The Stamp Tax or the Boston Tea Party, American foundrymen were drawn into the resistance when the British Parliament, in an act of economic tyranny, required all iron made in the colonies to be shipped to Britain and forbade the construction of new furnaces. As a result, there were six signatories to the Declaration of Independence who cast metal for a living. They not only put their necks on the line, but their products helped determine the outcome of the American Revolution. And one can only wonder what form our great governmer might have taken if Messrs. Hamilton, Madison, and Jay, did not have access to the invention of a metalcaster named Gutenberg to print and spread their ideas to the citizenry of our newly nascent country as it struggled to define a lasting form of government.

Against this brief historical backdrop, the point I wish to emphasize is that the metalcasting industry has always been one of strategic importance. Throughout its long tradition, this industry is not one that only *bore* witness to history--it very often *caused* it.

Last year, U.S. foundries shipped $30 billion of product, about 15% of which was defense related items. The industry employs 215,000 people in 3,100 facilities located across the U.S. It is an industry that epitomizes opportunity for small businesses in this country, as 80% of its plants employ fewer than 100 people.

Foundries have enjoyed some success as net exporters of many products, but in the last 25 years they have also exported more jobs than they currently offer--over 225,000--since during that time an average of 80 foundries every year had to shut their doors, succumbing to the pressures of foreign imports, changing markets, and the high cost of environmental and safety compliance.

However, metalcasters believe they have turned the corner. Their population has stabilized, and they have benefited from a strong economy in the past few years. But the fragmented nature of the industry begs a unifying force--a rallying point around which the industry can maintain and build upon its world class competitiveness into the next century.

This rallying point has been supplied by Congress through its support of the *Metalcasting Competitiveness Act* and by DOE, who has recognized the strategic nature of our industry and partnered with it. Last October, Secretary O'Leary and industry leaders signed a long term compact to collaborate on achieving industry-wide goals that will: reduce energy consumption; increase market development; develop new materials, manufacturing, and environmental technologies; enhance human resources and education; and foster further collaborative efforts.

The DOE Metalcasting Research program is a highly effective partnership between industry and government. This is a "can-do" program that has already delivered results where they are most needed--to thousands of small businesses across our nation. That is why the program has the enthusiastic support of the industry and DOE.

Since this program's inception, investment in technology development has increased many times over. Investment is difficult from small private companies, much of whose capital is invested in equipment mandated by regulatory compliance and whose margins are slim in a highly competitive market. And as an added benefit, the public investment has a magnetic quality that makes it easier for the industry to form consortia to raise private funds. Without this program, the industry's efforts to raise the funds needed for the advancement of critical technologies would be seriously impaired.

As a result of the good work started through Public Law 101-425, and through the participation of academic institutions, DOE labs, and matching monetary and in-kind contributions from the industry, metalcasters have already begun to realize the improvements they are capable of--not through handouts, but through cooperative effort. From the technology transfer and outreach programs pioneered at the University of Northern Iowa to the basic research being conducted at the Universities of Alabama, Ohio State, and Idaho State, to name but a few, the industry has already improved the viability, quality, and world competitiveness of its products.

It is appropriate that the industry's technical societies be closely involved with ongoing research efforts. They are extremely adept at organizing technical and matching financial support for specific research projects. However, I believe that taxpayers' dollars would be best invested in programs whose effectiveness was evaluated by independent peer review boards, such as the one I represent. These should be comprised of industry leaders appointed by and accountable to the Secretaries of the Departments under which programs are administered.

My head is counted among those who work in printing and publishing, but my heart is with those who toil in the melt shops and molding lines in this country. On behalf of these honest and hard working people, I urge the Members of this Subcommittee, and of both houses of Congress, to continue their support of programs to enhance one of America's basic and strategic industries.

This concludes my prepared testimony. I thank the Members present for their attention, and welcome any further questions.

Testimony

By

Dr. Harvey Forest
Chief Executive Officer
Photovoltaics
Amoco/Enron Solar
Frederick, Maryland

For the

Subcommittee on Energy and Environment of the House Committee on Science

On

Fiscal Year 1997 Budget Recommendations for

Solar Energy Programs

April 30, 1996
Washington, DC

Photovoltaics and Telecommunications: Synergistic Growth Industries

I. Executive Summary

Amoco/Enron Solar, through its Solarex Business Unit, is an active partner with both the US Departments of Energy and Commerce in programs that are advancing photovoltaic (solar electric) technology. Dr. Harvey Forest, CEO-Photovoltaics, Amoco/Enron Solar, presented testimony before the House Subcommittee on Energy and Water Development regarding FY 1997 Budget Recommendations for US Department of Energy Solar Energy Programs. A written version of this testimony is attached. This following text describes the relationship of on-going and potential future US government R&D programs to on-going and future markets for photovoltaic (PV) technology.

In summary, the US PV industry has made effective use of the R&D results developed under cost-shared R&D contracts with the US Department of Energy. The best measure of this effective partnership is the growth in sales of US based manufacturers and their share of the global market for PV products. Over the past several years the market for photovoltaics in two remote power applications, i.e. 1) rural electrification, and 2) stand-alone power systems for remote industrial applications, has grown at an average annual rate of roughly 20%. The share claimed by US based manufacturers has grown steadily as well. Moreover, US Department of Energy programs implemented in the last three years have begun to address the unique technical requirements of a third major emerging market, i.e. for on-grid solar photovoltaics applications. New programs for building integrated and other grid-tied solar applications have helped US utilities and US manufacturers test and improve skills and technologies necessary to the critical role photovoltaics will play in optimizing grid electricity supply systems in the US and around the world in the coming decades.

Meanwhile, the Advanced Technology Program of the US Department of Commerce has provided opportunities for commercially active solar manufacturers like Solarex to transfer technologies from non-energy industries into processes for the manufacture of solar equipment. As a result, Solarex is making good progress understanding the application of "rapid thermal processing" techniques to its manufacturing processes. This application has the potential to reduce product costs and thereby improve the competitive position of US manufacturers vis-à-vis competitors based in other countries. The indirect benefits include the creation of high quality jobs and more rapid penetration of emerging markets.

We believe that there is a need for such programs not only to continue but to focus on the synergistic combinations of technology that will enable cost-effective expansion and re-tooling of US and global telecommunications infrastructure. Photovoltaics is one of the technologies that will enable the transition to less capital intensive cellular communications, a transition that must occur to address the needs of emerging economies, and a transition that represents the fastest growing market for our photovoltaics and other twenty-first century core technologies. We encourage Congress to act on the need for a focused program to help position US industry for success in this emerging high-technology, high growth arena.

II. Situation Analysis

The on-going revolution in information and communications technologies is public knowledge and a matter of considerable legislative and regulatory attention. Major infrastructure-building investments are being made and planned. Photovoltaic technology already plays an important enabling role in expanding telecommunications capabilities world-wide. Historically, telecommunications applications have accounted for nearly half of the market for PV modules in recent years. To be more specific, using Solarex as an example:

- In the 1990's, Solarex and the US photovoltaics industry have experienced annual revenue growth in excess of 20%. This rapid growth is expected to continue.
- Since 1992, Solarex has increased its US employment base by nearly 30%.
- Approximately two-thirds of Solarex products are exported.
- Solarex is in the process of expanding its production capacity by a factor of three, so that in 1998, Solarex will have the capacity to manufacture three times the volume of photovoltaic modules that Solarex factories produced while operating at full capacity in 1994.

The success of PV products in the overall marketplace is based on PV's ability to cost effectively provide reliable, low disturbance, high quality electric power where it is needed. Low disturbance, high quality premium power is increasingly needed for the reliable operation of microprocessors which are sensitive to voltage fluctuations. Advanced telecommunications and power distribution systems are increasingly dependent on microprocessors and other power sensitive components. The Electric Power Research Institute (EPRI) estimates that currently 40% of all electricity in the United States flows through or is controlled by microprocessors/electronics. This percentage is expected to increase to 65% by the year 2000. This illustrates the increasing demand for low disturbance, reliable power sources. PV based systems produce power with enhanced quality which is ideally suited to meet this demand.

A revolution in building energy system technology is underway, enabled by distributed information and control systems. Building and home automation, which will allow integration of energy and communications systems, is a trend that will continue as communications and energy supply and distribution systems are opened to competition. The integration of PV into building exterior wall panel and roofing systems is perhaps the most economical current application of solar power generation technology. The cost for the PV power generation system is in part offset by the need not to use conventional wall and roofing systems which would normally be utilized on building structures. This type of application is commonly being used today in Japan and Europe.

PV panels are uniquely modular allowing customized power outputs for various power applications. Photovoltaics produce a DC power output making them ideally suited to power telecommunications equipment which typically utilizes DC power.

These features constitute value beyond what is possible from conventional power sources. The vast majority of PV products (~80% over the last years) are sold for off-grid applications. These products are providing electricity to places that are beyond the reach of the utility grid, many of which will remain so for the foreseeable future.

III. Opportunity Identification

Photovoltaics is a renewable, non-polluting energy source that will someday provide a significant share of the world's electricity. It is ideally suited to boost the energy supply infrastructure in parts of the world where demand is still too small and diffuse to justify the major investments required to deliver power from central station power plants via high voltage transmission systems. Approximately two billion people in the world do not have electricity in their homes. Rural electrification via the construction of new conventional central power stations and grid extension is not a near term option for most of these people. However, distributed PV based systems can cost-effectively provide timely, needed amounts of electricity at affordable costs.

Royal Dutch/Shell Group, perhaps the most successful predictor in the energy industry and the only oil company to anticipate both the 1973 oil price boom and the 1986 oil price bust, has predicted that PV will be the world's most rapidly growing form of commercial energy with sales exceeding $100 billion by the year 2030. Sales for all renewable energy sources are estimated at the time to be $150 billion.

Markets for rural electrification and remote industrial applications, such as telecommunications, are sustaining PV market growth. Meanwhile, telecommunications market growth is being sustained by the appetite for information in parts of the world where modern telecommunications infrastructures are not yet in place. Growth in both the PV and telecommunications markets will be synergistic, and there is an opportunity for the US government to catalyze the synergism to its own competitive advantage in global markets.

In such a scenario, PV can be best characterized as an "enabling" value-added technology since it enables reliable, high quality electricity to be generated where it is needed. Technologies that allow energy and communication infrastructure to be built up without networks of wires will provide high value products to satisfy the growth of the new communications industry. The ability for PV to generate power on a distributed, remote basis makes it an ideal technology to power wireless telecommunications systems which also utilize a distributed architecture. All of the major telecommunications companies, e.g. AT&T, Motorola, Alcatel, SR Telecommunications, are actively integrating PV into telephony systems. These systems are in place in countries as diverse as the United States, Saudi Arabia, India, Brazil, South Africa, and Indonesia. Strategies Unlimited has estimated that the world market for PV applications in the communications industry will increase from 20MW in 1995 to 60-95MW by the year 2005.

In these markets, PV modules are not purchased as an end in themselves, but rather to provide electricity to operate a variety of electronic loads from simple lights to large-scale telecommunication systems. When a PV system is purchased, the price of the PV modules is usually only a tiny fraction of the total system cost. PV turns non-consumers into consumers for the US electronics industry. Already, PV powers billions of dollars worth of electronic systems around the world.

In the near term, PV can turn the two billion people without access to electricity into consumers of other electrical and electronic goods. For example, PV can help sell cellular phones, communication systems, and even communication satellites to the vast majority of people in the world who have yet to make a telephone call.

IV. Role of Government in Technology and R&D Programs

Congress must weigh the need for government programs that foster US industrial research. Government-funded programs have made the US the world leader in computers, aerospace and biomedicine. The US technological leadership in both fuel cells and photovoltaics is attributable to government-funded programs.

A recent study by Rensselaer Polytechnic Institute's Lally School of Management and Technology states that government funding plays a larger-than-expected role in fostering long-term research and development. Federal funds speed the research process and reduce company risk in developing emerging technologies. Examples of successful and commercially available technology developments that began with funding from government programs are the Microwave & Millimeter Wave Monolithic Integrated Circuits (MMIC) technology and Texas Instruments' new display technology. Both programs began with funding from the Defense Department's Advanced Research Projects Agency (ARPA).

The US Department of Energy has a strong PV program that has done much to advance the technology. Consistent with its charter, the DOE program has as its goal the development of PV to provide a significant share of the US electricity supply. In response to this goal, the DOE program targets low cost grid-tied PV systems. The results of this program have contributed significantly to the commercial success of the US PV industry.

If Congress decides to simultaneously catalyze aggressive growth of the US electronics industry and off-grid PV infrastructure to enable this growth, programs involving different tactics and focus will be needed.

V. Strategic Response

Elements of such programs would include:

- Transfer of materials and materials processing technologies used in other industries to processes for the manufacture of PV based systems.
- Develop ultra-high reliability, non-interruptible PV power systems (with work on modules, controllers, regulators, energy storage and inverters).
- Optimize electronic and energy storage systems for use with PV.
- Design PV modules and integral electronics and energy storage components that can be directly integrated into buildings and structures associated with wireless communication systems (e.g., outdoor cabinets, base stations).

- Coordinate the technology forecasting and assessment efforts of the PV, communication, and telecommunications industries.

For maximum effectiveness, a program comprising these elements should be a cost shared cooperative effort involving US companies. Specifically, the focus should be to develop technologies for electronic products for use in remote areas of the world where no communications infrastructure exists. This program would help build new export markets for US high technology companies leading to the creation of new high tech jobs for US workers.

The Department of Energy's program could be expanded to respond to the opportunity, or the National Institute of Standards and Technology could establish a new focus program as part of the Department of Commerce Advanced Technology Program. The need for timely action should drive the choice. Other governments will also respond to the opportunity. Prompt action will make it possible for new markets to be developed by US companies, thus creating US jobs.

Testimony

by

Dr. Harvey Forest
Chief Executive Officer
Photovoltaics
Amoco/Enron Solar
Frederick, Maryland

Before the

House Subcommittee on Energy and Water Development

on

Fiscal Year 1997 Budget Recommendations for

Solar Energy Programs

of the

United States Department of Energy

February 29, 1996
Washington, D.C.

My name is Harvey Forest and I am the CEO for the Solarex Business Unit of Amoco/Enron Solar. Thank you for the opportunity to present Amoco/Enron Solar's recommendations regarding FY97 appropriations for the USDOE Photovoltaics (PV) Technology Program. My testimony will be in four parts.

Recommendations

First, I will suggest a new vision of PV as a strategic technology, because I believe a fresh look at PV by the Congress and the USDOE is warranted.

Second, I will summarize the results of Amoco/Enron Solar's first year of operations, because I believe our results accurately mirror the progress of the US PV industry and speak to the need for a fresh look at PV.

Third, I will recommend a balanced approach for the 1997 budget which supports technology development and rapid commercialization of grid-tied markets.

Fourth, I will recommend that Congress direct the Secretary of Energy to undertake a review of the strategic priorities of the US PV program, seeking input from market-driven PV companies.

A New Vision of PV as a Strategic Technology

As you know better than I, the rationale for US energy technology programs is based on concerns of energy independence and the long-term costs and availability of fossil fuels. Many of our emerging energy options, including PV, have progressed with the support of USDOE programs. Congress can rightly take pride in the accomplishments of these programs and their contribution to US energy security and fuel efficiency.

Many of these technologies are at the beginning of their life cycle. One does not need to look far to see examples of technologies developed to meet one need being put to use to meet another need. In many cases, new technologies enable one another, so that one innovation leads to numerous others. PV is such an enabling technology. A technology intended by the USDOE as an option for central station power in the US is now enabling thousands of rural families to enjoy electric light and television for the first time. It is bringing the benefits of electric appliances to developing areas of the world where traditional power grids may not reach for decades, if ever.

On a broader scale, it now appears unlikely that resources will be available to allow rural electrification to proceed globally following the model of grid extension used in the US and other developed countries. Moreover, the same situation exists in the expansion of the current telecommunications networks on a global scale. So, technologies that allow energy and communications infrastructure to be built up without networks of wires will provide high value products to satisfy the growth of the new communications industry. In addition, PV systems and wireless communications networks can be deployed immediately and not suffer from the long lead times of networks based on wires.

It takes a bit of imagination to realize that PV will play a crucial role in this new distributed infrastructure paradigm. I believe the time has come for inclusion of the broader value of PV in the planning and execution of our national program. I urge the Congress to determine and direct that PV should be managed as a strategic asset, not as just another energy option to be used when and if cheap fossil fuels are no longer cheap, but also as an enabling technology for other growing industries.

This review should look at the consequences of "business-as-usual" as well as the opportunities that will develop from a fresh look. The average citizen can easily understand that the entire planet cannot use fossil fuels at the rate we consume in the US without an economic and environmental impact. Yet we have no policy or plan to anticipate what will happen when the developing countries significantly increase their energy consumption.

Amoco/Enron Solar Progress

In its first year, the Amoco/Enron Solar joint venture executed the first year of its business plan and validated the assumptions on which the plan was based. Specifically, the Solarex business unit, the technology and manufacturing part of the joint venture, achieved record revenues and shipments, significantly expanded production capacity, increased our workforce, and completed the design and started construction of TF1, a full-scale factory for production of the next generation of commercial PV technology. Solarex also sold rooftop, grid-tied PV systems based on current generation technology at prices within a factor of two of the cost threshold for explosive market growth. Over the past two years, Solarex continued to increase its sales to global remote power markets while tripling its sales to grid-tied markets to more than 20% of overall shipments.

Meanwhile, the Amoco/Enron Solar Power Development business unit, the power marketing part of the joint venture, validated the ability to develop independent power projects, selling electricity from large PV arrays to utility grids around the world. The competitive economics of such projects are based on using thin film PV modules produced in factories like TF1. Such projects can be profitable and competitive with projects based on fossil fuels or other renewable technologies in areas receiving better-than-average annual accumulations of solar radiation. Such areas exist in the "sunbelt" of the globe, and are also close to major population centers and regions of high electricity demand growth.

A Balanced Program is Needed

Over its history, the USDOE PV technology program has done an excellent job striking a balance between two major categories of activity. These categories are: building the knowledge base for technical progress, and working with our industry to tackle the technology barriers to rapid commercialization. My message to you is simply that this strategy must be sustained. It is important to Amoco/Enron Solar and the entire PV industry that the USDOE respond to budgetary pressures in a way that preserves this essential balance. Further, it is important that program balance reflect our industry's readiness to begin developing grid-tied markets for PV, along with finding ways PV can enable the long-term optimization of US communications infrastructure and distributed energy systems. In many cases, this will mean strengthening and adjusting certain elements of the USDOE program, while completing others as planned, rather than simply making across-the-board adjustments.

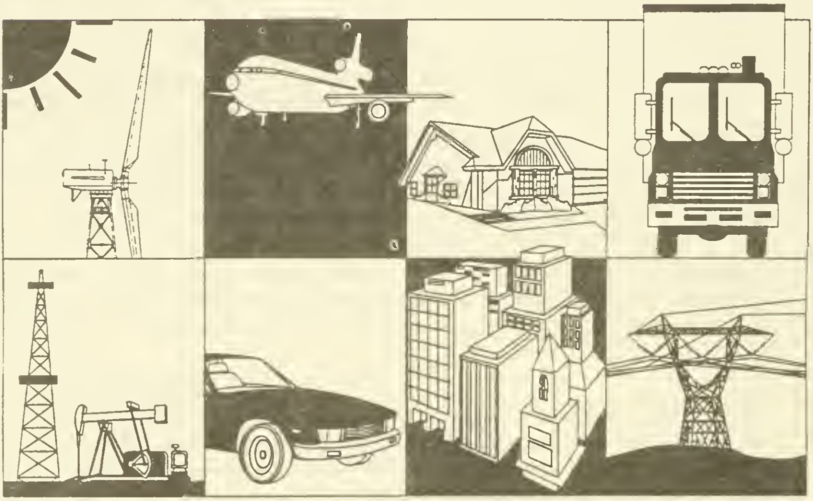
We are confident a balance can be struck, and we would like to share our experience with those charged with accomplishing this difficult task. We can best articulate our views and contribute our expertise in the context of a process to examine and up-date overall program priorities. For this reason, I urge the Congress to require the Secretary of Energy to conduct a thorough and open review of the program's priorities and report the results to this and other relevant committees of the House and Senate. Such a review is overdue. The review should include input from various sources, including market-driven PV companies. Its results can be used to assure that the USDOE program provides effective support of the US PV industry's on-going success in global markets. This review will guide future expenditures to provide US taxpayers the maximum return on their strategic investment in PV technology.

APPENDIX 2—

Additional Materials For The Record

Success Stories: The Energy Mission in the Marketplace

A Portfolio of
Successful Investments in Applied Energy Research and Development
by the U.S. Department of Energy



Helping To Make America
Clean, Efficient, Competitive, and Secure

U.S. Department of Energy

Prepared by
Office of Policy
U.S. Department of Energy
Washington, DC 20585

Success Stories: The Energy Mission in the Marketplace

Energy Mission

The Department of Energy's mission and its civilian energy research and development (R&D) programs are motivated by a number of important and enduring public policy objectives. These objectives are rooted in national security, economic, environmental, and scientific leadership considerations. They reflect the pervasive role that energy plays in modern society. They are underpinned by a respectful understanding of history and of the unique vulnerabilities that our Nation faces with regard to certain aspects of long-term energy supply and end-use.

Role of Federal R&D

Accordingly, the Department's applied energy R&D programs fill an important gap in the United States' R&D continuum. This gap is where it is clearly in the *public interest* to pursue certain technological opportunities, especially those that are long-term or high-risk, but where for economic reasons it is not in the *market's interest* to do so.

The reasons for this gap are many. One is that the public benefits, such as national security or environmental quality, are simply not fully reflected in market prices. Another is that private firms are finding it increasingly difficult to recoup their R&D costs by appropriating exclusively to themselves the true benefits of the R&D. In today's highly competitive global market, technical secrets are short-lived and too easily stolen, scientists are hired away, and inventions are slightly modified in order to circumvent intellectual property rights. More fundamentally, the R&D itself is often too challenging, requiring large interdisciplinary teams of scientists, working year after year on expensive and unique laboratory equipment. Finally, the structure of certain industries is often too fragmented, or the firms too small, to mount the sustained R&D campaign necessary for success.

Within this context, the proper role for the U.S. Department of Energy's applied R&D programs is *not* to subsidize or displace private sector responsibilities for R&D, but to complement them selectively in ways that will help achieve important long-term public policy objectives and that are justified by one or more of the special market circumstances outlined above.

What Successes?

So, after nearly two decades of investing in such R&D at the U.S. Department of Energy, is it fair to ask "What benefits have accrued to the U.S. economy?"

Yes, it is—and the answer is impressive. Many outputs of the Department's R&D, conducted in pursuit of its public policy objectives, not only have had substantial economic success in the marketplace, but also have proven to be fundamentally important in one technical area after another in positioning U.S. industry at the forefront of global competition. In today's markets, winning products are often those with technically driven advantages in performance and price, and the Department's R&D has contributed significantly to many of these winning products.

Among such products is the electronic ballast for fluorescent lighting fixtures that has become the lighting technology-of-choice. It has already saved U.S. electricity consumers $750 million, a saving that grows every day. Another technology, low-emissivity window coatings, has gained a 34-percent market share of all new double-glazed residential windows.

And, the economic benefits of the Department's programs will continue well into the future. Four technologies in one building technologies R&D program are expected to net more than $16 billion in economic savings to U.S. taxpayers by the year 2015, far outstripping the total past and projected Department of Energy investments in this area of R&D.

These statistics may surprise some critics of the Department's R&D programs. Many of the Department's most important R&D contributions lie in the "precompetitive" stages of technology development, or in important intermediate technology components, and such contributions are often hidden in the final product. Many people might recognize the technological sophistication of modern commercial trucks and diesel engines, Boeing 757 and 767 aircraft, and high-efficiency lights, windows, and appliances; but few would realize that Department of Energy technology is inside those products and is responsible, in part, for their fast-growing global market shares.

To be sure, the Department has embarked on some R&D activities without yet achieving the desired results, and some of these are highly visible and costly. As with most high-risk ventures, targets cannot always be met, both in private and public sector R&D programs. The purpose of the Department's R&D programs is to explore these high-risk technical possibilities.

Many of the bold experiments in energy demonstration projects of the late 1970s, motivated by global conflict and national security concerns over oil, are now seen in hindsight as having been too ambitious. Some expensive technology pushes are no longer supported—for example, synthetic fuels, the Clinch River Breeder Reactor, magnetohydrodynamics, and the Stirling automobile engine—because they were not economically successful, even though they produced a wealth of scientific knowledge and engineering experience. But these are only a part of the picture.

Improved R&D Productivity

More fundamentally, the Department's record of R&D productivity has steadily improved over nearly two decades of R&D investment. Management techniques for R&D have become more sophisticated and less congressionally directed. They are now squarely rooted in competition, driven by technical merit and scientific peer review, and aligned with the needs of cost-sharing industrial partners.

Economic Successes

This report compiles a brief list of some of the more significant Department-sponsored technology developments that have already had, or will have in the next year or so, significant impacts on the U.S. economy. It omits hundreds of scientifically and technically important developments and focuses only on examples of successes with major economic significance.

As a word of caution, please note that the pathway of scientific discovery, from basic research to product development, is often complex and multifaceted. Bringing a new product to market involves many players, and credit for their existence should be shared broadly. The final stages of development are almost always, as they should be, private sector interests. The products that consumers see rarely have any overt indication of an underlying Federal or Department of Energy R&D role.

This does not mean, however, that the R&D was not important, or that it would have been developed anyway if just given enough time. The examples in this report show that the Department of Energy's R&D programs played a key and enabling role in the resulting technology development. The Department does not claim credit for the final design and production of the commercial products. Nor does it wish to understate the critical importance of the private sector's role. It does want to emphasize, however, the collaborative nature of scientific discovery and technology development, with private and public actors each playing distinct and complementary roles.

R&D Management Principles

The Department's programs support high-risk, precompetitive research. The Department's applied energy R&D investments are guided by a set of R&D management principles, which limits and carefully guides the use, and guards against the misuse, of public funds for R&D. The Department supports R&D if and when serious shortfalls occur in areas of R&D otherwise important to society.

R&D Considerations

The Department of Energy's decisionmaking on investment in R&D takes into consideration the following factors:

- The overall significance of the potential benefits of the R&D to the Nation.
- The level of technical difficulty of the task and whether the overall risk of the R&D is such that private industry will not undertake the development on a timely basis.
- The nature of the R&D and whether or not an individual firm might recover its research costs by appropriating to itself the benefits of the knowledge (a "public good") it creates.
- The nature of the industry and whether the fragmented structure of an industry might work against sufficient levels of R&D spending because its firms are too small to undertake certain kinds of R&D projects.
- The distance from commercialization, where certain proprietary sensitivities otherwise might adversely affect private sector competition.

Deficit Reduction or Revenue Enhancement?

Given these considerations, the Department's funding of applied energy R&D is a well-founded, complementary public investment in the advancement of science and technology in areas critically important to the Nation's future. Upon this enabling foundation of precompetitive research and knowledge, corporate America can build and market its own commercial products, which is the proper domain of the private sector.

These successes result in new products and processes that compete successfully in global competition and employ U.S. workers in high value-added jobs, who pay taxes on their income. These technologies reduce costs to businesses and consumers, which stimulates the economic growth of the Nation and adds to corporate taxable profits, all of which return revenue to the Treasury.

Accordingly, a case can be made that an investment in the Department's applied energy R&D programs should not be viewed as a current operating expense on the deficit side of the Federal budget account, but rather as a high-risk portfolio of capital investments in the Nation's future, with a predictable portion resulting in significant economic paybacks that are already adding net revenue to the income side of the Federal ledger. These R&D investments not only produce public benefits, but make money for the U.S. Treasury.

Increasing Energy Efficiency

Energy-efficiency improvements in homes, commercial buildings, transportation, and industry can contribute significantly to offsetting increased energy demand while freeing up capital for use elsewhere. Benefits from demand reduction include avoiding costly capital investments in electric capacity, lessening reliance on imported energy supplies, and reducing harmful emissions.

The Department of Energy aims to develop cost-effective energy-efficiency technologies that protect the environment and support the Nation's economic competitiveness. To achieve this goal, the Department emphasizes carefully targeted cost-shared collaborations with public and private enterprises. U.S. industry is increasingly involved in developing and using these technologies, thanks to the efforts of the Department.

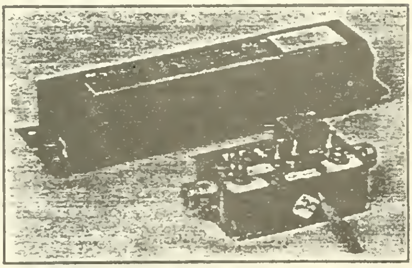
Our programs in these areas carry out the Department's responsibility under the Energy Policy Act of 1992 (EPACT) and other major pieces of authorizing legislation. The benefits of the Department's efficiency programs—to industries, homeowners, and commercial firms—can be measured in cost savings, productivity gains, new high-value jobs created, and improved productivity and competitiveness for U.S. industry. The following paragraphs highlight some of the successes that have flowed from these programs.

Building Technologies

Residential and commercial buildings consume more than one-third of all U.S. primary energy and about two-thirds of the Nation's electricity. To help realize the energy security, economic, and environmental benefits of improved energy efficiency in buildings, the Department supports research and development on building systems, envelope, and equipment.

Fluorescent Lamp Electronic Ballasts

Department of Energy research and development created the current state-of-the-art electronic fluorescent lighting ballast, which was unknown in the mid-1970s. The electronic ballast not only improved lighting quality, but has **saved consumers $750 million in consumer energy bills** from a $3 million research and development investment. This new industry's sales totalled $275 million in 1992.

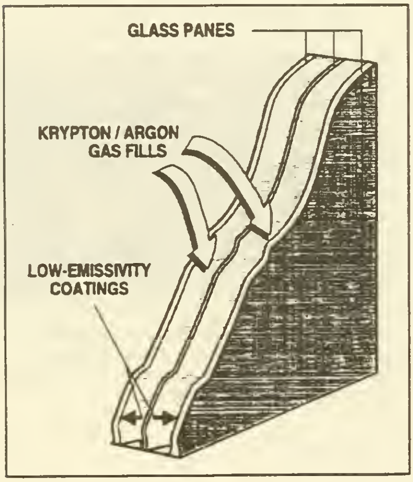


Electronic ballasts (upper) have saved consumers $750 million. In foreground is a lab prototype electronic ballast for low power electrodeless lamps (for example, the sulfur lamp).

accounting for 25 percent of total ballast sales. Electronic ballasts are expected to replace magnetic ballasts in at least 75 percent of applications by 2015.

Advanced Energy-Efficient Windows

A 20-year Department of Energy research and development partnership with industry culminated in the development at Lawrence Berkeley Laboratory of an advanced energy-efficient window that uses low-emissivity coatings to block heat gain or loss. **No U.S. manufacturer had invested in this technology before the Department's R&D investment. Cumulative consumer energy savings attributable to using low-emissivity windows are $1.8 billion.** This enormous savings was leveraged and catalyzed by a Department of Energy investment of just $3 million through the early 1980s. The Department teamed with five window manufacturers (Andersen, Cardinal IG, Owens-Corning Fiberglass, Pella, and Southwall Technologies) and the Bonneville Power Administration to convert the concept into commercial prototypes. Today, **every major glass and window manufacturer offers low-emissivity products.** Their market share is one-third of all residential windows.



Energy-efficient window.

Sulfur Lamp

In October 1994, the Department of Energy and a small Maryland company, Fusion Lighting Inc., unveiled the sulfur lamp, or S-Lamp, a revolutionary new type of light system in which microwaves are used to heat a sulfur core. The S-Lamp is a scientific and technological breakthrough, considerably more efficient than even fluorescent lights, with fewer associated environmental problems. The quality of light is vastly improved, more nearly approximating natural sunlight, and the installation costs are one-sixth that of conventional lighting. At present, the new system is being demonstrated at the Department's Headquarters, where it lights the outdoor entrance to the building, as well as at the Smithsonian Air and Space Museum. **Two S-Lamp bulbs have replaced 240 mercury bulbs, providing four times the light at one-third the cost.** Unlike other high-efficiency lamps, the Sulfur Lamp uses no mercury and produces 50 percent less ultraviolet light. The United States uses 520 billion kilowatt hours annually for lighting. The S-lamp is expected to have enormous potential commercial and residential applications.

Computerized Analytical Tool for Energy-Efficient Building Design

Department of Energy research and development has created a powerful analytical software tool, DOE–2, for reducing energy use in buildings. DOE–2 calculates hourly building energy use and cost from information on the building's construction, climate, operation, heating, ventilating, and air-conditioning systems, and utility rate schedule. At least 5 percent of commercial buildings today are designed with DOE–2. **Use of the software accounts for $1.9 billion in energy savings for buildings constructed** through 1993.

High-Efficiency Refrigerator/Freezer Compressor

From 1978 through 1980, the Department of Energy, through Oak Ridge National Laboratory, sponsored a contract with Columbus Products Co. to develop a high-efficiency compressor for household refrigerators. The resulting product achieved a 44-percent improvement over the compressor technology used in refrigerators at the time. The availability of high-efficiency compressors was a major reason that refrigerator energy use dropped from about 1,300 kilowatthour per year in 1980 to about 900 kilowatthour per year in 1990. Use of the improved compressors pioneered by this research effort has **saved consumers at least $6 billion in energy costs from 1980 through 1990.**

Flame Retention Head Oil Burner

In the early 1970s, concern with oil supply and price volatility increased interest in improving the efficiency of oil use. The Department of Energy sponsored field testing by the Oil Heat Research and Development Program at Brookhaven National Laboratory, which established the energy conservation benefits of the retention head oil burner. A second Department effort published the findings in a consumer-oriented information booklet. In several years the retention head burner achieved total dominance of the market for new and replacement oil burners. **Consumer energy cost savings to date from this innovation total more than $5 billion.**

Flame Quality Indicator

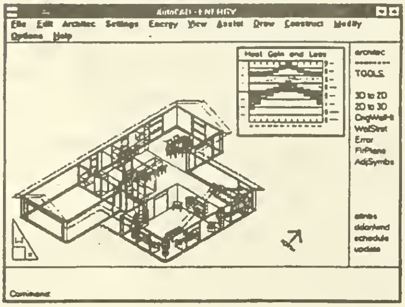
The flame quality indicator, developed by the Oil Heat Research and Development Program at Brookhaven National Laboratory, has been called the most significant advance in oil heating technology since the introduction of the flame retention head burner in the 1980s. The flame quality indicator ensures that the burner operates at peak efficiency throughout the year by monitoring the brightness of the oil burner flame and warning the consumer when the burner needs maintenance. From a Department of Energy investment of slightly more than $1 million, this technology potentially can **reduce oil use by 290 million gallons per year, which represents $3 billion to consumers over 10 years.** Currently, three licensed manufacturers have entered the market. **The flame quality indicator received the 1992 R&D Magazine R&D 100 award and the 1993 "Best of What's New" from Popular Science magazine.**

Compact Fluorescent Lamps With Convective Venting

Compact fluorescent lamps produce less light and operate at reduced efficiencies at the elevated temperatures often associated with constricted environments (such as within recessed fixtures). A Department of Energy laboratory has received a 1994 Federal Laboratory Consortium Award for Excellence for developing a convective venting method to alleviate this problem. The cooling action produced by the convective venting yields an approximate 18-percent increase in lumen output, **while increasing lamp service life from 750 to 10,000 hours.** This approach has been adopted by several large fixture manufacturers (Delray Lighting, Lithonia, Kurt Versen, and Prescolite).

Softdesk Energy Building Software

A collaboration among the Department of Energy, the University of Oregon, and Softdesk, Inc., resulted in Softdesk Energy, a software building design system that incorporates energy-saving features into computer-based building designs. The program integrates specialized software, computer-aided drafting tools, and commonly used manual tools for energy-use estimation. Used during the design process, the one-of-a-kind system provides quick feedback on a building's future energy consumption. The system also determines energy use impacts from internal factors such as lighting, temperature, humidity, ventilation, and building use. Softdesk Energy requires minimal input from the architect, which significantly reduces design time and costs and encourages the exploration of energy-efficient building designs. The system is designed and equipped to incorporate other energy design



Computer software aids design of energy-efficient buildings.

tools such as code and standards compliance, lighting design tools, detailed energy analysis packages, and heating, ventilation, and air conditioning equipment selection tools. **Of 167,000 computer-aided building design users, 100,000 (60 percent) are Softdesk Energy users.**

Appliance Efficiency Standards

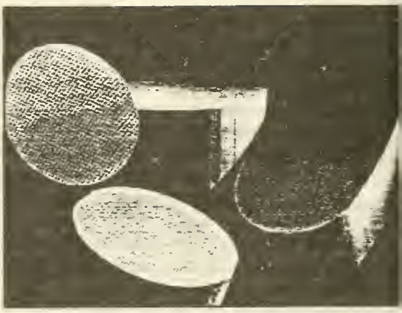
The Department of Energy is required by law to set energy-efficiency standards for a number of appliances, including refrigerators and freezers, stoves and ovens, dishwashers, water heaters, and heating and cooling equipment. The Department updates the standards to ensure that models coming onto the market incorporate the best available efficiency technologies. **These standards have already saved U.S. consumers nearly $2 billion on their energy bills.** Consumers save $2.50 on energy bills for every extra $1 paid to purchase appliances meeting the efficiency standards.

Transportation Technologies

The U.S. transportation sector is still almost totally dependent on oil, and it consumes more than 60 percent of the oil used in this country. Reducing the Nation's vulnerability to oil disruptions will require major changes in the transportation sector's energy demand patterns. Achieving improvements in air quality is also linked to breakthroughs in transportation propulsion technology, as well as changes in the mix of fuels used for transporting people and freight. To accelerate the introduction of more efficient, less polluting transportation technologies, the Department's activities focus on advanced propulsion systems, improved materials, and cost and performance improvements.

Ceramic Regenerator Matrix/Catalytic Exhaust Converters for Automobiles and Heavy-Duty Engines

The Department of Energy research and development in ceramic turbine and materials programs is spawning an entirely new industry with many spin-off components. As an example, the Department's ceramic regenerator development work provided the technological "roots" for a catalytic converter that is now commonly used to reduce automotive emissions. **Current sales of such ceramic components for automobiles are $600 million per year worldwide and are expanding.** Other component sales are projected at $1 billion and 10,000 jobs for the year 2000. Corning Incorporated holds the largest market share.



Ceramic substrates for automotive catalytic converters upon which platinum catalyst is deposited.

Silicon Carbide Whisker-Reinforced Ceramics

Silicon carbide whisker-reinforced ceramics developed by the Department of Energy have increased machining rates up to 800 percent and have dramatically decreased the frequency of cutting tool replacement. These advantages have allowed the United States to recapture a substantial international market share of the cutting tools industry. This composite material was developed in coordinated Department programs with a 7-year **investment of $3.8 million; worldwide sales now exceed $30 million.**

Sintered Silicon Carbide Used as a Seal Face in Automotive Water Pumps

The Department of Energy Transportation Materials Technology Program, with the Carborundum Company, has developed an improved sintered silicon carbide (ceramic) seal face for water pumps. These seals are used in 30 percent of new U.S. automobiles—up from 5 percent in 1993. Shipments will total 10 million seal faces this year for worldwide

Sintered silicon carbide steel faces for automotive water pumps.

markets. A Department of Energy investment in mechanical characterization of approximately $500,000 over a 5-year period has resulted in a potential **worldwide market for these seals in excess of 65 million units per year.**

AC Electric Drive Train

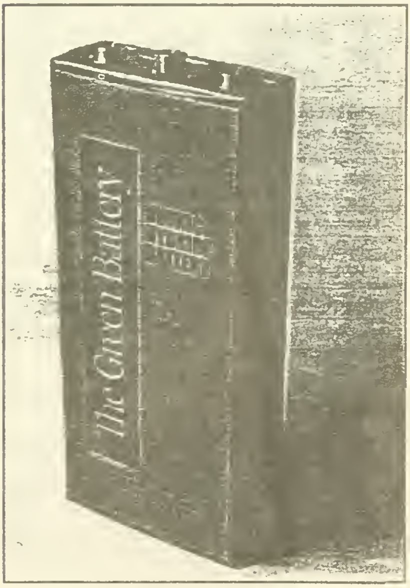
Under a cost-shared contract with the Department of Energy, the Ford Motor Company and General Electric have developed a new electric drive train. This drive train uses one design for a wide range of production vehicles. This new multivehicle design will reduce consumer costs and allow electric vehicles to enter the market sooner. Ford is testing this technology in 105 Ecostar electric vehicles operating around the country. The California laws mandating zero-emission vehicles will result in **approximately $70 million in electric vehicle sales in 1998 (the only current solution to the California mandates), growing to $350 million by the** year 2003. Should the New England states implement the California mandates, the market will grow to at least $1 billion by 2003.

Ceramic Material Heat Engine Components

High melting temperatures, hardness, light weight, and other properties of ceramic materials promise to enable energy efficiency, emissions reduction, and durability improvements in automobile and truck engines. The Department has worked with industry to develop processes that have improved the properties and reliability of ceramics. In 1983, ceramic heat engine parts repeatedly broke. Ten years and $109 million of DOE cost-shared research and development has resulted in U.S. industrial ceramic materials that **exceed the strength, durability, and reliability requirements for transportation applications.** The Department has developed a process, with a U.S. company, to reduce the cost of producing silicon nitride ceramic powder from $30 per pound to slightly more than $10 per pound. The ultimate goal is $6 per pound. Manufacturers are beginning to use this material for a variety of parts in production engines. Allied Signal, for example, is manufacturing ceramic oil pump spacers for use in commercial aircraft, including Boeing, Gulfstream, and Airbus. As another example, more than 15,000 ceramic cotter pins have been sold for aircraft applications.

Nickel Metal Hydride Cells, Modules, and Vehicle Batteries

Nickel metal hydride batteries are one of three midterm batteries being developed by the Department of Energy through the United States Advanced



A nickel metal hydride battery.

Battery Consortium. This battery technology is approaching all of the consortium's midterm goals, with the exception of cost. The consortium is now concentrating on developing lower cost materials and improved production processes. Given the performance of this technology, General Motors has formed a joint venture with the Ovonic Battery Company. Replacing the lead acid battery in the General Motors Impact car with this nickel metal hydride battery will increase the range of the vehicle from 70 miles to 140 miles between recharges. A conservative market estimate for this battery, as the result of the mandates for zero emission vehicles in California and the Northeastern States, is **approximately $350 million in 2003.**

Biomass Feedstock Technology

Hybrid poplar "supertrees," which are being commercially planted by six major pulp and paper companies in the Pacific Northwest, were developed through Department of Energy investment in research programs for producing biofuels feedstocks. This portion of the Department's Biofuels Feedstock Development Program, focused in the Northwest, has invested approximately $2 million over 17 years to produce genetically superior trees and improved agricultural production techniques. **Acreage planted is expected to double from the 25,000 acres planted now to well over 50,000 acres within the next 2 years.** Two mills are already using the fiber to produce paper as well as energy for their boilers, and two new nursery companies have emerged to supply high-quality cuttings to private industry and landowners. The Western Washington plantings established along rivers provide habitat to an endangered deer species and other wildlife. Each acre of hybrid poplars planted displaces the need to harvest 10 acres of Douglas Fir for fiber.

DYNA3D Finite Element Analysis Technology

The Department of Energy sponsored research that developed DYNA3D, a dynamic finite element analysis tailored to simulate high energy impacts, such as car crashes or aircraft collisions with birds. DYNA3D is available at near-zero cost to the public and has had a major impact on U.S. industry. It is used by more than 300 U.S. companies, including GE Aircraft Engines, General Motors, Chrysler, the Boeing Company, ALCOA, General Atomics, FMC Corporation, and Lockheed Missiles and Space Company. The technology is used by all U.S. car manufacturers and has sharply reduced the need for costly vehicle crash testing. An independent study placed the **savings to U.S. industry as a result of using the model at $350 million.**

Zymomonas Mobilis Organism

In 1994, research sponsored by the Department of Energy developed a new, genetically engineered organism, *Zymomonas mobilis*. This organism enhances the fermentation of cellulose, increasing the rate of conversion and yields of ethanol for use as fuel. It is estimated that this new technology, which was described in the prestigious journal, *Science*, and widely written about by the Associated Press, has **significantly reduced the cost of ethanol** from $3.60 per gallon to less than $1.00 per gallon, making ethanol a more competitive alternative fuel.

Lightweight Materials Technology Development

Reducing vehicle weight through the use of lightweight materials promises to enable major energy efficiency improvements in full-size automobiles without compromising passenger comfort and safety. At the program's inception in 1992, lightweight metals such as aluminum could not compete with steel as the material of choice for automotive manufacturing because of their cost and forming time. After three years and $3 million of Department of Energy cost-shared R&D, advanced forming of aluminum sheets for auto body components achieved weight reductions of 43 percent, parts count reductions of 89 percent, forming time reductions of 77 percent, and cost reductions of 15 percent. **Projected cost savings to auto companies are about $60 million per year by 1997.**

Industrial Technologies

The Department's industrial energy activities are motivated by energy, economic, and environmental policy objectives. Specific activities are shaped by the recognition that enhanced energy efficiency is a key to increasing industrial productivity and that improving efficiency of industrial energy use is closely linked to reducing waste and pollution. The goal of the industrial energy program is the creation of a more efficient, competitive, environmentally sound, and sustainable domestic industry, and to promote environmental stewardship, competitiveness, and job preservation and creation by demonstrating profitable alternative approaches to regulatory compliance.

The Department collaborates with industry to reduce energy use through new technologies in heat recovery, energy utilization, and industrial and municipal waste management. Other programs develop process improvements and innovations for specific energy-intensive industries such as pulp and paper, steel, and chemicals. In addition, applied research in combustion, biotechnology, advanced materials, and heat transfer will provide the foundation for future advances in technology. An active technology transfer program provides an effective link between the research and development programs and the community of potential users.

More than 50 technologies in the Department of Energy's Industrial Technologies Program are economically successful. An investment in developing these technologies of about $1.1 billion from fiscal year 1977 through 1994 has yielded approximately **$2.5 billion in energy savings and capital productivity.**

Catalytic Distillation

The advanced catalytic distillation process developed by the Department of Energy nearly 15 years ago has become a major commercial success. It is used to produce gasoline additives such as methyl-tertiary-butyl-ether and tertiary-amyl-methyl-ether, thus helping U.S. refiners produce the reformulated gasoline mandated by the Clean Air Act Amendments of 1990. As of fiscal year 1994, 80 units were on order at the manufacturer, Chemical Research and Licensing, Inc., 19 units were operating in the United States, and 40 units were operating worldwide—28 percent of the world market. **Advanced catalytic distillation saved 3.24 trillion British thermal units of energy in 1993 alone, at a rate of about $10 million per year.**

Ultralight Aerogels

Scientists sponsored by the Department of Energy at two national laboratories have developed a new material, called aerogel, that has the lowest density, highest porosity, lowest thermal conductivity, and lowest sound propagation of any solid ever made. A **1-inch-thick layer of aerogel replaces 12 inches of fiberglass insulation.** This feature is particularly valuable in appliances such as refrigerators and water heaters. While industry interest in better insulation is being explored, the unique properties of aerogel have opened other market opportunities for this emerging technology. Because of their high surface-to-volume ratio, these materials can be used as catalytic and adsorbent surfaces and as carbon ultracapacitors. Ultralight aerogels are being taken to the commercial market by Aerojet, a segment of GenCorp.

Aluminum Remelting Technology

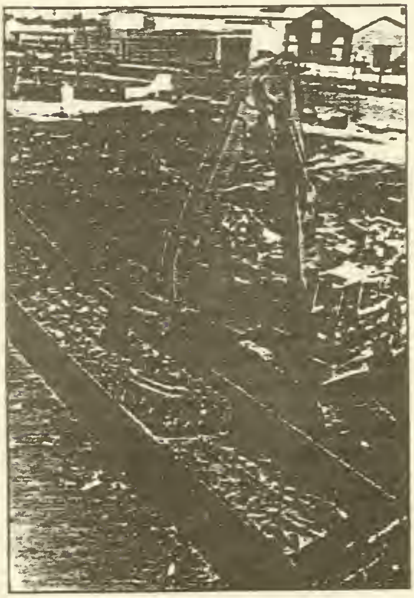
A $400,000 grant from the Department of Energy, through the National Industrial Competitiveness Through Energy, Economics, and Environment program to AAP St. Mary's of Ohio has resulted in a more efficient technology for aluminum remelting. By avoiding the second aluminum chip melt during recycling, real energy savings are 6.36 billion British thermal units annually—6,249 gallons of diesel fuel, and 155,000 gallons of coolant. Additionally, the new technology eliminates 59 tons per year of emissions and 64 tons per year of dross. **Dollar savings equal $642,000 annually.**

Vacuum Pressure Swing Adsorption

By eliminating the nitrogen from air in glassmaking furnaces burning gas or oil, vacuum pressure swing adsorption technology has reduced furnace emissions of nitrogen oxides by 90 percent and particulates by 25 percent. Furnace energy requirements are reduced by 25 percent. Three companies, Praxair, Inc., (Tarrytown, N.Y.), Corning, Inc., (Corning, N.Y.), and Gallo Glass Company (Modesto, California) have commercialized this energy-efficient technology. **Approximately 15 percent of all glass made in the United States now employs this technology.**

Electrochemical Dezincing of Steel Scrap

Department of Energy scientists have developed an electrochemical method of removing the galvanized coatings from steel scrap that would allow 10 million tons of this valuable resource to be used in steelmaking furnaces. This process would increase production yields and quality as well as decrease environmental problems and cost. By the year 2000, electrochemical dezincing could save **50 trillion British thermal units of energy,** reduce raw material costs by at least $160 million per year, and reduce the need to import at least 75,000 tons per year of zinc, saving at least $77 million annually.



A crane loads 3,000-pound bales of dezinced steel. This stamping plant scrap was dezinced using the electrochemical process developed by the Department of Energy.

High-Efficiency Weld Unit

Improving power supply efficiency is key to achieving significant energy savings in welding processes. Conventional arc-welding power supplies use a low-frequency transformer, which makes them power-inefficient and unwieldy in weight and size. The Department of Energy developed a more efficient power supply with the Cyclomatics Company. The new system uses solid-state electronics known as inverter technology to shut off power to essentially all of the power source components when a unit is idling. This reduces electrical energy consumption by up to 45 percent compared to conventional power supplies. Nationwide, these units have saved more than 13 trillion British thermal units of energy and can be credited with reducing emissions of carbon dioxide by 20,000 tons each year. **Annual savings are $15 million.**

Direct Steelmaking

The Department of Energy supported post-combustion research in a Basic Oxygen Steelmaking Furnace, which led to the application of the technology in the electric arc furnace. The result is a savings of 40 to 50 kilowatthour per ton and a 6- to 7-percent increase in productivity. This work was performed by Union Carbide, now Praxair, under a subcontract from the American Iron and Steel Institute. Praxair is now marketing the technology worldwide. This technology can be applied in approximately 50 million tons of steelmaking annually, with an **annual savings of $30 million.**

Superplastic Metal Formation Technology

The superplastic metal forming process developed through research sponsored by the Department of Energy allows the manufacture of metal components into shapes very near final dimension. This results in several advantages. It minimizes machining material waste, eliminates the use of environmentally damaging solvents, and saves energy, time, and labor costs. Further, it allows the use of new materials such as lightweight alloys, and enhances design freedom by creating the opportunity to produce unique complex shapes. **Manufacturers report a 20-percent savings in metal machining processes.**

Securing Future Energy Supplies

Today more than 85 percent of the useful energy and power produced in the United States comes from boilers, furnaces, and internal combustion engines that rely on fossil fuels. The Nation's increasing dependence on imported oil makes us vulnerable to supply disruptions and related price shocks. Although natural gas and coal are mostly domestic fuels, the heavy reliance on fossil fuels necessitates costly efforts to control pollution. Improving the Nation's ability to develop cleaner technologies and secure future energy supplies is vital to our economic, environmental, and social well-being.

The Department of Energy seeks to achieve this goal by research and applied technology development aimed at diversifying energy sources—especially promoting increased use of indigenous resources, including oil, gas, coal, nuclear, and renewable energy. We also support efforts to increase the efficiency of electric energy distribution and storage. To better ensure early commercial application of successful technologies, this research and development will be based on cost-shared joint government-industry-university collaborations wherever possible.

Some success stories on the supply side of the energy ledger are highlighted in the following paragraphs.

Renewable Energy

The Department supports a balanced development and deployment effort on promising renewable energy technologies aimed at increasing the production and use of domestic energy resources, and is working with industry to strengthen the technology base leading to new products and processes for the commercial market. The number of private-sector partners willing to cost-share key research projects is evidence that the private sector has a legitimate interest in these technologies. Research and development on photovoltaics, solar thermal, wind, biomass, and geothermal energy will help strengthen the Nation's energy security, promote sustainable energy approaches, and increase U.S. industrial competitiveness. The goal in this program area is to triple the U.S. nonhydropower renewable energy capacity by the year 2000.

Continued cost reductions fostered by our strategic research, development, and deployment activities can ensure the United States a place in an emerging multibillion-dollar clean energy market. The establishment of footholds by U.S.-based firms in international sales activity is clearly vital. Currently, U.S. photovoltaic and geothermal companies are worldwide leaders as a result of Department of Energy investments in advanced technology development. More than 70 percent of U.S. photovoltaic manufacturing output is exported, resulting in more than $90 million in annual revenues. U.S. companies have installed more than 1,000 megawatts of geothermal facilities in other countries and have orders for an additional 2,000 megawatts, creating an annual income stream of $250 million.

Photovoltaics

Research and development supported by the Department of Energy has been instrumental in the discovery, synthesis, and development of state-of-the-art semiconducting and photonic materials and devices. Photovoltaic technology converts photons (light) into electricity. Today photovoltaic cells power a wide variety of devices, including spacecraft, watches, calculators, highway signs, navigational aids, emergency telephones, and relay stations; in developing countries, photovoltaic cells power entire remote villages. Photovoltaic systems are an ideal, environmentally sensitive technology for bringing people in remote sites such basic services and amenities as light, water, communications, power for businesses, and power for other productive uses.

Photovoltaic electricity costs dropped from 90 cents per kilowatthour in 1980 to 20 cents per kilowatthour today. Since 1988, photovoltaic output has doubled; photovoltaic output increased another 24 percent just from 1993 to 1994. Maintaining and expanding this phenomenal growth depends on continuous improvements in the performance and cost-competitiveness of photovoltaic products, supported through cost-shared R&D between industry and the Department of Energy. At present, **every $100 million in direct module photovoltaic sales helps support or create 3,800 U.S. jobs.**

Wind Turbine Technology

Collaborative Department of Energy and industry research and development has created today's modern wind turbines, which are already providing sufficient electricity for 1 million Americans. Costs have been reduced from almost $.25 per kilowatthour in 1980 to the current range of $.05 to $.07 per kilowatthour in locations with good wind resources. New wind turbine blades, advanced materials development, and developments in airfoil technology are expected to further reduce the cost of wind-generated electricity to $.04 per kilowatthour by 2000. In California alone, there are more than 1,700 megawatts of generating capacity. California's wind powerplants **currently provide up to 8 percent of Pacific Gas and Electric's load and save the energy equivalent of 4.4 million barrels** of oil each year while producing no air pollution. (In fact, wind power prevents the creation of 2.5 million tons of carbon dioxide and 15,000 tons of other pollutants per year.)

Wind Energy Analysis Systems

A team of scientists at a Department of Energy laboratory produced and documented the most comprehensive analyses available of wind energy resources and wind electric potential in the United States. These analyses are used by utilities, energy planners, and industry. Team members also combined their skills to develop a measurement and analysis system for characterizing turbulence in the wind inflow to a turbine rotor. Efforts are now being extended across the globe to assist developing countries in establishing local wind energy projects. Data derived from the research also convinced the World Bank to include wind power as a viable option for a **$600 million rural electrification project in Indonesia. This investment directly serves the Department of Energy missions of pollution prevention and increased energy efficiency.**

Geothermal Technologies

The commercially operated geothermal site at The Geysers in northern California reached peak electric power output of 2,000 megawatts in 1988. Inexplicably, a steady decline in output began in 1989. In 1990, a concerned geothermal industry asked the Department of Energy for assistance in determining the cause. Failure of power production at The Geysers would have a depressing effect on all potential markets for geothermal power. During fiscal years 1990 through 1994, the Department of Energy shared costs with a coalition of geothermal operators and made available both experts and expertise to help diagnose the problem. The cause proved to be reservoir fluid depletion, the result of inadequate reinjection practices and insufficient knowledge of reservoir management requirements. The lessons learned in this effort will continue to benefit geothermal reservoir development for years to come. With a $12 million Department of Energy investment—matched by $42 million from industry—a potential crisis for hydrothermal energy systems was overcome, reservoir practices leading to **decades of stable operation** were developed, and **more than 300 jobs were directly preserved.**

Gas and Oil Exploration and Production Technologies

Oil remains one of our Nation's vital commodities, supplying 40 percent of the United States' primary energy needs and nearly all of its transportation fuel. Domestic production, however, continues to decline, with two-thirds of all the oil ever found in the United States remaining unrecoverable by conventional production methods. Moreover, the United States has technically recoverable reserves of 113 billion barrels, almost 6 times today's proved reserves. In addition, as much as 1,300 trillion cubic feet of natural gas is technically recoverable in the lower 48 States—about 8 times more than current proved reserves.

To realize the potential of these oil and gas resources requires continued development of advanced exploration and extraction technologies. The Department is working with industry to develop advanced computing technologies to improve drilling success rates, rock drilling systems for natural gas, and advanced oil recovery technologies, as well as carrying out related research and analytical activities. By enhancing the efficiency and competitiveness of U.S. industry, these research and development efforts will increase domestic energy production, reduce dependence on imports, and create jobs.

Polycrystalline Diamond Drill Bits

Research and development sponsored by the Department of Energy produced one of the most important advances in drilling technology, a new drill bit design that uses polycrystalline diamond cutters. Previous diamond cutting bits failed when the cutting assembly would break away from the bit after prolonged drilling. This technology, which was spawned by Defense Programs basic research at Sandia National Laboratories, permanently bonds the cutters to the bit. In time-critical drilling situations, this drill bit can **save as much as $1 million per well**. Worldwide, 13 companies now fabricate this synthetic diamond drill bit. U.S. companies produce approximately 4,000 bits per year.

Mudpulse Telemetry for Measurement While Drilling

One of the most important timesaving innovations used today in the drilling industry is the "measurement-while-drilling" instrument. Before its invention, operators needing to determine drill bit direction had to cease drilling, remove hundreds or thousands of feet of drill pipe, and lower an instrument into the well. Readings would then be taken, the instrument retrieved, and drilling would recommence. In the 1970s, the Department of Energy helped Teleco, Inc., pioneer a wireless system that could transmit the location of a drill bit by sending pressure pulses through the drilling mud that circulated from the bit face to the surface. Today, mudpulse telemetry has gained wide acceptance in

Polycrystaline diamond drill bit is one of the most important advances in drilling technology. Thirteen companies currently manufacture the bit.

the drilling industry and is estimated to have saved **the natural gas and oil industry at least $1 billion over the past 20 years.**

Carbon Dioxide Sand Fracture Production Technology

The Department of Energy's Morgantown Energy Technology Center developed, tested, and helped commercialize this technology for stimulating production from natural gas wells. A nondamaging treatment process, it won the natural gas industry's **1994 Best Technology in the Northeast Award.** Of special importance to small, independent producers, the technology has been shown to increase production by 200 to 500 percent. At $2.00 per thousand cubic feet, a 3 to 9 million cubic foot well using carbon dioxide sand fracturing **will generate $20 million more revenue over its productive life.**

Hot Oiling Paraffin Treatment

Buildup of paraffin in the wellbore and near-wellbore formation can cause severe reductions in production of waxy crudes and result in lifting equipment failures. Traditional batch treatments are expensive and can result in formation damage if sound hot oiling practices are not followed, that is, if melted paraffin solidifies before it reaches the bottom of the well and plugs the formation. The Department of Energy developed a computer model that optimizes hot oiling paraffin treatments and aids in determining good practices. The use of this software, to estimate downhole temperatures and effectiveness of hot oiling, helps both producers (especially independents) and service companies by reducing operating and maintenance costs. For example, application of the software by an independent producer in a West Texas field increased the efficiency of production equipment, reduced equipment failures, and resulted in about $1.00 per barrel-equivalent reduction in average lifting cost. Industrywide use of the software and good hot oiling practices could result in **more than $150 million per year in reduced operating cost,** and also reduce well abandonments.

Insulating Doughnut for Steam Flood of Deeper Oil Wells

Steam injected into deeper heavy-oil wells can lose significant amounts of heat during the trip from the surface to the reservoir. In fact, a phenomenon known as wellbore refluxing can result in up to six times the heat loss in an uninsulated tubing string than would be normally expected. Sandia National Laboratories, working under a Department of Energy program, devised a 2-inch-long "doughnut" of plastic insulation that, when inserted in the standard tubing coupling, prevents steam from contacting the thin outer coupling walls. Heat loss through refluxing is reduced substantially. This simple device is now standard in the industry, and the savings to the industry will amount to **hundreds of millions of dollars over the next decade.**

Improved Oil Recovery Technology for the Green River Formation

An oil recovery field demonstration program cosponsored by the Department of Energy has shown that by properly applying improved waterflooding technology in the Uinta Basin in Utah's Green River Formation, additional oil can be produced from fields that might otherwise have been abandoned. The Department's test has turned around conventional thinking in the region, giving Utah producers a technology that was previously thought to be unusable in the region's complex geology. The initial field test has already added **2.4 million barrels of producible oil to the region's reserves.** More importantly, neighboring operators have begun using the technology and will **return more than $160 million in Federal taxes and royalties, well above the $112 million Federal investment** to date. Ultimately, recoverable oil reserves in Utah could be expanded by 3.5 billion barrels because of the Department of Energy cost-shared project.

Carbon Dioxide Miscible Flooding Technology for Oil Recovery

Three percent of all domestic crude oil (about **180,000 barrels per day**) is produced by injecting carbon dioxide into aging reservoirs to force out oil that conventional production techniques cannot recover. The gas mixes with some of the remaining oil in the reservoir, and creates a miscible bank of fluid that pushes additional oil to production wells. In large part, industry gained confidence in carbon dioxide flooding technology through a series of eight field tests conducted in the 1970s and co-financed by oil companies and the Department of Energy and its predecessors. Because of the success of carbon dioxide-enhanced oil recovery, carbon dioxide pipelines have been built throughout west Texas and eastern New Mexico, the principal regions of successful carbon dioxide miscible flooding. With the completion of the LaBarge pipeline, carbon dioxide-enhanced recovery has also been extended to oil fields in Wyoming and could reach others in North Dakota. Today, roughly **68,000 Americans are employed** directly and indirectly because of this oil recovery technology. Moreover, data developed through the Department's laboratory research has saved the domestic oil producers **at least $10 million** by allowing them to accelerate development of other recovery processes.

Computerized Oil Field Simulators

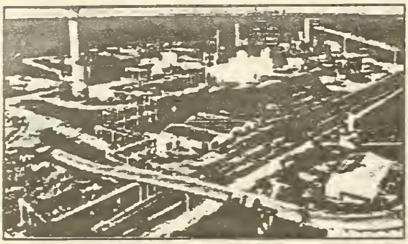
Closely related to predictive models is a family of oil field simulation software developed by the Department of Energy. BOAST (Black Oil Applied Simulation Tool) was introduced in 1982 as a way to simulate the movement of oil, gas, and water through an oil reservoir. BOAST has been upgraded to operate on personal computers and expanded to assess larger areas, larger numbers of wells, and more solution options. More than 2,400 copies of BOAST PC software have been distributed by the Department. Several oil industry consulting firms have modified the program to their own specifications. **More than 20 million barrels of oil** have been produced as a result of using these simulators, and **the return to the taxpayer is more than $1,000 for each $1 of Department of Energy investment**. Universities are also using BOAST as a textbook for reservoir simulation instruction. A second simulator, UTCHEM, has been developed specifically for chemical flooding. The simulator is being used by approximately 20 oil companies to project the behavior of tracers, polymers, polymer gels, surfactants, and alkaline agents injected into oil reservoirs. Better management of reservoirs has saved these companies **more than $23 million, $8 million of which will flow back to the U.S. Treasury.** The Department developed a third simulator, MASTER, to assist the natural gas industry in evaluating miscible and nonmiscible gas-enhanced oil recovery processes. By 1994, more than 250 copies of the software package had been distributed. Studies indicate that use of these processes will generate a 3-billion barrel increase in potential reserves.

Foam Fracturing of Gas Reservoirs

Another technique for creating fractures in a gas reservoir is to inject foam under high pressure into the wellbore. Foam has an advantage over high pressure water injection because it does not create as much damage to the formation, and well cleanup operations are less costly. Before the mid-1970s, use of foam fracturing was limited almost exclusively to Canada and the Rocky Mountain region. The Department's research in the late 1970s extended the technology to the Eastern region of the country, where effective fracturing is required to produce commercial quantities of gas from shale formations. More than 50 stimulation tests were conducted to apprise oil and gas operators in 8 Eastern States of the technique's merit. Once it was shown that the process **accelerates the rate of natural gas production from these wells by nearly 200 percent,** the foam fracture process became the dominant stimulation technique for marginal gas wells in the United States.

Enhanced Oil Recovery Predictive Models

The Department of Energy, in partnership with the National Petroleum Council and Software/Intercomp, has developed easy-to-use, predictive computer models for numerous enhanced oil recovery techniques. More than 1,000 copies of the PC-based predictive models have been distributed to oil field operators, drilling and service companies, consultants, researchers, and several major oil companies. The use of these models has **saved the industry $400 million** by screening out uneconomical projects.



The Wabash River Coal Gasification Repowering Project, about 70-percent complete by the end of 1994. Destec Energy's two-stage, oxygen-blown gasifier tower is on the right and the integrated gasification combined cycle heat exchanger, and stack is on the left.

Coal-Use Technologies

Coal is the Nation's most abundant fossil fuel and is currently used to generate 57 percent of U.S. electric power. With coal projected to remain a dominant fuel for the power industry for many years, cleaner and more efficient coal-based technologies are becoming increasingly important for the Nation's energy and economic future. Working in close collaboration with industry, the Department's research and development efforts focus on improving the environmental acceptability of coal. These include developing technologies to burn coal more cleanly and efficiently, as well as technologies that can reduce the costs of producing liquid transportation fuels from coal.

Integrated Gasification Combined Cycle

Capitalizing on a successful gasification program, the Department of Energy has provided the foundation for an advanced power generation system that will be the powerplant of the 21st century. Advanced integrated gasification combined cycle (IGCC) technology will have system efficiencies ranging from 41 to 52 percent. Emissions of sulfur dioxide and nitrous oxide are limited to less than one-tenth of that allowed by New Source Performance Standards, carbon dioxide emissions are reduced by 35 to 45 percent, and solid waste is reduced by 40 to 50 percent. The IGCC powerplant is cost-competitive to build, in fact it is projected to be significantly less costly than conventional powerplants, while the cost of production would be reduced by 10 to 20 percent. At present, the Department's Clean Coal Technology program will provide the IGCC system entry into the global market as a top-ranking clean coal power generation technology with a **potential global market of more than $400 billion in capital investment by 2030, and about $150 billion in the domestic market.**

Super 9 Chrome Alloy

During the 1980s, Department of Energy research and development was instrumental in the development of a superstrong alloy called Super 9 Chrome, which is now used worldwide as an industry standard for improving the safety and reliability of equipment in coal-fired powerplants. This 9 percent chromium and 1 percent molybdenum alloy improves the life and performance of equipment under the severe operating temperature, pressure, and corrosion conditions typical of fossil fuel plants. Department of Energy scientists received the prestigious R&D 100 Award for this technology, which has since been incorporated into American Society of Mechanical Engineers Boiler and Pressure codes and transferred directly to industry for commercial applications. **Sales of this product exceed $100 million to date**. Use of this alloy has enabled an increase in coal-fired powerplant efficiency of more than 3 percent, which results in a **savings of more than $1.7 million per year in fuel costs in a typical 500 MW powerplant.** The higher efficiency also results in reduced emissions of sulfur dioxide, nitrogen oxides, and particulates, as well as reduced production of carbon dioxide by 280,000 tons per year.

Atmospheric Fluidized Bed Coal Combustor

The most significant advance in coal-fired boiler technology in more than half a century, the Fluidized Bed Coal Combustor has been the commercial success story of the last decade in the power generation business. This state-of-the-art, low-polluting combustion system technology has progressed into even larger scale utility applications. To date, **more**

than $6 billion in domestic sales and $2 billion in foreign sales have been achieved through this Department of Energy investment. Domestic sales alone translate into nearly 250,000 jobs. Every major U.S. boiler manufacturer now offers a fluidized bed combustor in its product line.

Low Nitrogen Oxide Burner

With nitrogen oxides targeted for reduction by the 1990 Clean Air Act Amendments, Low Nitrogen Oxide Burner technology developed by the Department of Energy and Altex Technologies Company has rapidly found its way into the power market. **Domestic sales to date total more than $250 million, supporting 1,800 U.S. jobs.** For wall-fired boilers, nitrogen oxide reduction levels of 35 to 40 percent are achieved at a capital cost of about $20 per kilowatthour and a levelized cost of about $280 per ton of nitrogen oxide removed. For tangentially fired boilers, the same degree of nitrogen oxide reduction is achieved at a capital cost of $15 to $20 per kilowatthour and a levelized cost of $220 to $350 per ton of nitrogen oxide removed. These costs are significantly lower than other options.

Pure Air Scrubber

The first utility in the United States to meet new Clean Air Act standards for sulfur dioxide control did so using an advanced technology supported by the Department of Energy, the Pure Air Scrubber. The capital cost per unit was half of previous air scrubbers, and it produces a commercially marketable gypsum material, rather than the waste sludge commonly produced by older scrubbers (which causes landfill problems). In one year, the Pure Air Scrubber is eliminating 50,000 tons of sulfur dioxide emissions, turning an air pollutant into enough wallboard to construct nearly 19,000 homes. **The project earned Power Magazine's 1993 "Power Plant of the Year" award.**

Powerplant equipped with a pure air scrubber system.

Micro-Mag Sulfur Removal Process

Application of the Micro-Mag sulfur removal process removes 80 percent or more mineral-bound sulfur in coal. Scientists supported by the Department of Energy received a Federal Laboratory Consortium annual award for excellence for developing and transferring this technology to the private sector. This technology is central to a **$900 million coal preparation and slurry pipeline energy project in China.** The China project alone, developed by Custom Coals Corporation, will support **6,300 U.S. jobs.**

Advanced Instrumentation Development

The Department of Energy's advanced instrumentation development efforts have generated and contributed to several commercial businesses, while fulfilling its role of supporting advanced and conventional power systems. The instrumentation developed in this program includes novel elemental analyzers, combustion turbine flame monitors, a steam quality monitor for advanced heat exchanger applications, and an on-line, real-time particle counter. The instrumentation applications range from optimizing environmental performance to process monitors for reduction of off-specification operations. The commercial value of the instrumentation installed **in current operating plants exceeds $40 million.**

Ceramic Composite Filters for Hot Gas Cleanup

The Department of Energy developed a process that produces continuous fiber ceramic composite filters that will reduce tons of pollutants and save millions of dollars in cleanup costs at hundreds of fossil fuel powerplants across the U.S and elsewhere. Subsequently, Department of Energy scientists developed a chemical vapor infiltration and deposition process to produce filters many more times more resistant to thermal and mechanical shock than conventional filters. 3M is now beginning to market the filter technology worldwide. **The annual market share for the filters is estimated to be $200 million per year.**

Slagging Advisor Software Model

The Slagging Advisor Software Model, the result of an industry, university, and Department of Energy team in laboratory coal science, is being marketed worldwide by PSI Powerserve. By optimizing control of boiler fouling, the software improves efficiency and cost in both conventional and advanced systems. Potential industrywide savings are hundreds of millions per year. For example, the software has **saved more than $1 million annually for one utility alone.**

Nuclear Fission Technologies

Nuclear energy currently provides approximately 20 percent of the electricity supply of the United States. Maintaining nuclear energy as an option to meet the Nation's growing demand for energy is one objective of the Department of Energy. Nuclear energy can provide a secure and clean domestic source of energy generation without emissions of greenhouse gases or acid rain precursors. Conducted in cooperation with the electric utility and nuclear industries, the Department's civilian nuclear energy program is focused on advanced light-water reactors that are expected to be safer, more reliable, and less expensive than current-generation nuclear energy plants. By working toward making standardized, certified, advanced light-water-reactor designs available before the end of the 1990s, the Department will help ensure that nuclear energy remains an option for the Nation's energy supply in the 21st century.

Light-Water Reactors

Although the bulk of the Department of Energy's work on light-water reactors was conducted over many decades, including the 1950s and 1960s, the Department continued to research important refinements in the 1970s and 1980s to improve safety and reduce costs. Based upon Department of Energy research and development in nuclear physics, reactor engineering, and related materials development, there are currently 109 nuclear powerplants (about 100 gigawatts-electric) with full power operating licenses. These powerplants produce approximately 22 percent of the Nation's electricity. The electrical power produced by these plants, if replaced by conventional powerplants, is equivalent to $20 billion per year. **Over the past 20 years, these plants have replaced the equivalent of $400 billion in fossil power**, displacing significant amounts of air pollution. Additional Department of Energy research in partnership with the nuclear industry is leading to procedures to extend the life of existing plants. Estimated savings in energy costs for 20-year life-extension versus replacement is $800 million per plant.

Extended Burnup of Light Water Reactor Fuel

By 1985, a 10-year research and development partnership between the Department of Energy and the nuclear fuel industry had provided the technology for an approximate 50-percent increase in the burnup (or energy extraction) achieved by each unit of nuclear fuel. This technology is being implemented in operating water-cooled reactors worldwide, yielding **fuel cost savings of several million dollars per year for each operating reactor,** reducing the amount of spent fuel to be disposed of by approximately one-third, and serving U.S. nonproliferation policy interests by making the reprocessing of such spent fuel even more uneconomical.

Greenhouse Gas Emissions Reduction

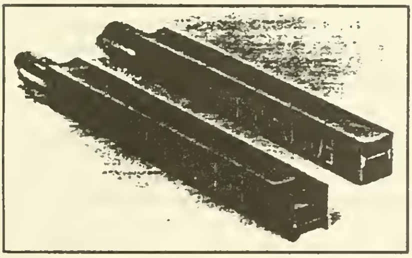
Department of Energy nuclear research has resulted in 92 percent of all carbon dioxide emission reductions realized in the electric utility sector since 1973, avoiding 1,615 million metric tons of carbon emissions. Also, nuclear energy has mitigated 27 million tons of nitrogen oxide and 65 million tons of sulfur dioxide emissions in the United States alone. Internationally, emissions avoided from 1973 through 1991 through the use of U.S. nuclear energy technology is 4,300 million metric tons of carbon dioxide, 70 million tons of nitrogen oxide, and 160 million tons of sulfur dioxide.

Advanced Light-Water Reactors

The Department of Energy supports research and development to make the next generation of nuclear powerplants, certified advanced light-water reactors, available at the earliest possible date to the marketplace, to ensure the light water reactor is an option in contributing to the new electrical energy capacity required by 2010. In 1994, Final Design Approval, a major milestone toward certification, was achieved for two 1,350-megawatt evolutionary advanced light-water reactor designs. The Senate noted this success in its report on the Energy and Water Appropriation Bill of 1995. Building on research and development sponsored by the Department, the **General Electric Company recently sold two advanced boiling water reactor plants to Tokyo Electric Power Company,** kicking off sales of the next generation in advanced light-water reactors.

Reduced-Enrichment Fuels for Research and Test Reactors

During the 1980s, the Department of Energy's Reduced Enrichment Research and Test Reactor Program at Argonne National Laboratory developed and qualified a high-density dispersion fuel that **serves U.S. nonproliferation policy interests** by significantly decreasing the amount of weapons-grade uranium being used for civil programs throughout the world. The U_3Si_2 dispersion fuel has received the Innovation Research 100 award (1985), has been accepted by all major research reactor regulatory authorities, and is currently being manufactured commercially in the United States, France, and Denmark. Additionally, fuel fabricators in Canada, Indonesia, and the United Kingdom are in the process of adopting the U_3Si_2 fuel. Through 1994, seven foreign and seven U.S. reactors have converted or begun to convert to this low-enriched fuel. Ten other reactors were converted to low enrichment uranium using lower density fuels also developed by the program.



Mock-up standard and control fuel elements fabricated during conversion of the Ford Nuclear Reactor at the University of Michigan to low-enriched uranium fuel.

Isotopes

As a direct result of energy research, Department of Energy national laboratories have been producing and distributing isotopes and isotope services and meeting national isotope needs in nuclear medicine, industrial, and research applications for nearly 50 years. Continued domestic isotope production and its ongoing transfer to private industry fulfills a vital national need. In the United States, isotopes are used in 36,000 diagnostic procedures and 50,000 therapeutic applications daily, **with more than 30 million medical uses valued at $7 billion to $10 billion each year.** One promising new medical therapy uses Yttrium-90, currently supplied to several major U.S. cancer treatment institutions. **The precommercial research and development success of Yttrium-90 cancer therapy has interested a number of commercial pharmaceutical companies.** Savings to U.S. patients could approach hundreds of millions of dollars in improved cancer treatment. The Yttrium-90 is obtained from Strontium-90, a nuclear waste product.

Radioisotope Thermoelectric Generators

The Department of Energy has developed and provided radioisotope thermoelectric generators (RTGs) to power spacecraft used in the exploration of outer space (24 missions) for more than 30 years. **These deep space missions would not have been possible without the RTGs.** RTGs convert heat from the radioactive decay of plutonium-238 directly into electricity. They are powering experiments left on the moon by Apollo astronauts, as well as experiments on Mars. The RTGs provide the enabling power for the Pioneer and Voyager spacecraft that have studied Jupiter, Saturn and Neptune and continue to send back data from beyond our solar system. RTGs power the Galileo spacecraft that is on its way to orbit Jupiter and that provided pictures of the recent Levy-Shoemaker comet impact. RTGs also power the Ulysses spacecraft that is the first such craft to study the polar regions of the Sun. By powering NASA spacecraft, RTGs have made a major contribution to our knowledge of the universe.

Advanced Electricity Generation and Storage Technologies

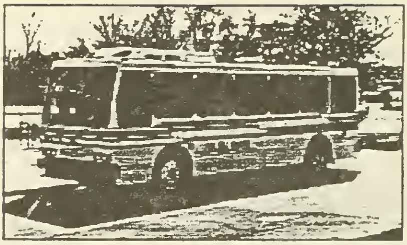
The convenience and flexibility of electric power have made this energy form a basic component of our economy and way of life. As previously discussed, the Department of Energy supports R&D activities that focus on improving the economics, environmental acceptability, and efficiency of conventional and emerging technologies. But in addition, the Department has been actively working on a variety of advanced electric technologies, some of which do not fit neatly into specific program areas.

For example, the Department's Office of Fossil Energy and Office of Energy Efficiency and Renewable Energy have been working with industry on an accelerated program to develop advanced gas-fired turbine systems and fuel cell systems. The new generation of electric power generating systems are expected to have environmental performances and fuel-to-electricity efficiencies that are much improved over today's conventional technologies. Other crosscutting technological areas include large- and small-scale electricity-storage technologies.

Phosphoric Acid Fuel Cells

A Federal investment in the 1980s and early 1990s yielded a radically new approach for commercial power generation, the fuel cell, and positioned the United States as the world leader in fuel cell technology. Relying on electrochemistry rather than combustion, the fuel cell is attractive for both heavily polluted urban areas and remote applications.

The phosphoric acid fuel cell was the first technology to emerge from one joint public-private, cost-shared program sponsored by the Department of Energy. Seventy-five 200-kilowatt commercial onsite cogeneration systems have been sold throughout the world, including 31 in the United States, by International Fuel Cells Corporation of South Windsor, Connecticut. One of these fuel cells, operated by Southern California Gas, set a record last year for uninterrupted operation at more than 80 percent efficiency. Phosphoric acid fuel cells have also been successfully developed by the Department for transportation applications. A fuel-cell-powered bus, now undergoing field testing, demonstrates significant energy benefits (twice the fuel economy of comparable diesel buses) and environmental benefits (emissions reduced by more than 99 percent compared to diesel buses). The projected annual sales of fuel cell technologies could total **more than $1 billion by 2020, a market that could create as many as 100,000 U.S. jobs.**



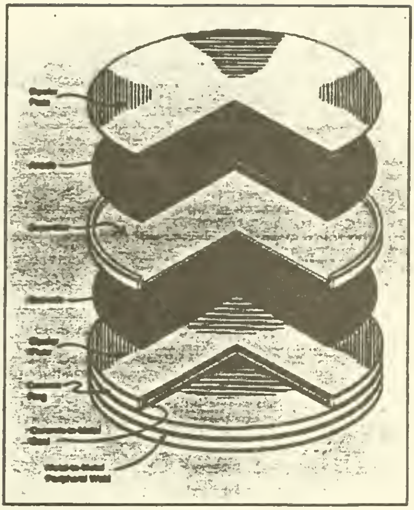
An urban bus powered by phosphoric acid fuel cells developed by the Department of Energy. This bus demonstrates twice the fuel economy and a 99-percent reduction in emissions when compared with equivalent diesel buses.

Advanced Gas Turbine Components

The Department of Energy is cost-sharing an 8-year development program to produce a leapfrog advanced gas turbine technology that will ensure continued U.S. leadership in the global market. While the entire turbine system will not be completed until the year 2000, key components have already emerged from the development effort and are being used in commercial turbines. In late 1994, Westinghouse Corporation announced a new type of industrial gas turbine, the 501G, the most fuel-efficient machine in its class. Advanced technology from the Department's R&D program is incorporated into the turbine. Closed-loop steam cooling of blades and rotors, techniques developed in the joint government-industry program, have effectively eliminated efficiency losses caused by earlier methods of air cooling. Although the United States dominates the global turbine market, foreign vendors are closing the gap. The leapfrog turbine emerging from the Department's program is expected to **maintain U.S. dominance in a multibillion dollar world market.**

High-Energy Batteries for Consumer Products

Investigations supported by the Department of Energy of nonaqueous electrolytes such as propylene carbonate provided the fundamental information needed to develop batteries based on electrolytes. High-energy primary (nonrechargeable) lithium batteries, which were not available prior to this research, are now in widespread commercial use. New generations of these electrolytes are also employed in secondary (rechargeable) lithium batteries now under development and in early stages of commercialization. The commercial use of such high-energy batteries has accompanied and enabled **the explosive growth of the multibillion-dollar portable electronics industry,** which includes laptop computers and portable tools. The technology can also be used in home and auto security systems, electronic tools, robotics, and medical instruments.



Rechargeable bipolar lithium iron disulfide battery stack.

GAO
United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-270917

April 15, 1996

The Honorable John R. Kasich
Chairman, Committee on the Budget
House of Representatives

Dear Mr. Chairman:

You asked us to review the Department of Energy's (DOE) report Success Stories: The Energy Mission in the Market Place. Specifically, you asked us to determine whether (1) the claims DOE makes in the report are valid and (2) Success Stories can be used to assess the value of DOE's applied research and development (R&D) programs. As you know, DOE's applied R&D programs are designed to support the development of technologies that accomplish the nation's energy objectives, such as securing future energy supplies. In fiscal year 1995, DOE received appropriations of about $1.65 billion, or about 9.5 percent of its total budget, to fund its applied energy R&D programs. Some Members of Congress and the Congressional Budget Office (CBO) have questioned whether the federal government's investment in these programs is cost-effective.

DOE published Success Stories in May 1995 to respond to these concerns. The report briefly describes 61 technologies developed or supported by DOE's applied R&D programs. Each case study highlights how a technology resulted in measurable benefits, such as securing future energy supplies. To address your questions about the report, we evaluated the support for the benefits claimed for 15 of the cases. We selected our sample to include (1) cases representing a cross section of DOE's applied research programs and (2) cases that cited large quantified benefits.

In summary, we found the following:

-- Although Success Stories makes some valid claims about the benefits of DOE's applied research, we found problems with the analyses DOE used to support the benefits cited in 11 out of the 15 cases we reviewed. These problems include basic math errors, problems in the supporting economic analyses, and unsupported links between the benefits cited and DOE's role or the technology. These problems make DOE's estimates of the benefits for these cases questionable.

-- While Success Stories shows that DOE's applied R&D programs do produce some benefits, it cannot be used to assess the effectiveness of DOE's applied research programs overall because it only describes the "successes" of a very small percentage of the projects DOE has funded. In addition, Success Stories does not report how much DOE spent to support any of the technologies we evaluated. Without a comparison of costs and benefits, the success of DOE's applied energy R&D programs cannot be determined.

BACKGROUND

For many years, DOE has devoted significant resources to energy R&D. From fiscal year 1978 through fiscal year 1993--the last year for which actual spending data are available--DOE spent $45.5 billion on R&D.[1] DOE's spending constituted over 48 percent of all domestic spending on energy research in fiscal year 1993. DOE received appropriations of about $2.37 billion in fiscal year 1995 for its research programs. Since the mid-1980s, DOE has dedicated about 70 percent of its total spending in energy R&D to applied research, which develops scientific knowledge that has specific commercial applications.[2] DOE has also invested significant amounts in basic research. Basic research is directed at increasing the understanding of energy phenomena without regard for immediate commercial objectives. In fiscal year 1995, DOE received appropriations of $726 million for basic research in such areas as materials and chemical sciences.

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[1] Figures are in 1994 dollars.

[2] To estimate DOE's spending, we obtained DOE's historical budget data, then applied the budget categories for basic and applied research developed by the Secretary of Energy Advisory Board's Task Force on Strategic Energy Research and Development.

Critics have maintained that applied research should be performed by the private sector, not the government. Also, in a March 1994 report,[3] CBO contended that few successful technologies have emerged as a result of DOE's applied R&D programs.

To prepare Success Stories, DOE's Office of Science Policy first asked its applied research program offices to provide examples of technologies they had developed that produced quantifiable benefits. Officials from this office then chose what they considered the best examples to include in the report on the basis of the significance of the R&D in terms of DOE's mission, quantifiable measures of its impact, and other factors. They also selected cases that illustrate the range of DOE's applied research programs.

The resulting Success Stories report provides brief case studies of 61 technologies that were developed or otherwise supported by DOE's applied R&D programs. The cases presented in the report vary greatly according to the size and type of the research project, the types of benefits attributed to the project, the time at which the benefits occur, and the sophistication of the methods DOE used to estimate the benefits. For example, some describe relatively small DOE R&D projects that were completed years ago, while others discuss multimillion dollar efforts still under way, such as DOE's photovoltaic program, which has been directed at developing ways to convert solar energy into electricity since the 1970s.

In describing the different types of economic benefits attributable to the technologies, some case studies cite how a technology has conserved energy, cut production costs, or increased energy supplies, while others attribute increased exports or environmental benefits to the new technology. Similarly, the cases differ in the time frames in which the estimated benefits are achieved. Some cases estimate benefits that have accrued for one year, some estimate benefits throughout the 1980s and early 1990s, and others project benefits for recent or ongoing R&D efforts that will not occur before 2000. More importantly, DOE used different approaches or methodologies to estimate the benefits. In some cases, the analyses supporting the examples use market models or other sophisticated techniques, while in other cases the analyses rely on other approaches, such as available sales data or an expert's best judgment about future markets.

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[3] Reducing the Deficit: Spending and Revenue Options, Congressional Budget Office, Mar. 1994. CBO's February 1995 report on the same subject no longer specifically states that few successful technologies have emerged from DOE's applied R&D programs. However, the report states that many lawmakers have questioned the value to the economy of those R&D programs.

The 15 case studies we selected for detailed review (1) covered all major program areas and fuel sources and (2) accounted for most of the large economic benefits identified by the report.[4]

REPORT CITES SUPPORTABLE BENEFITS BUT CONTAINS MANY WEAKNESSES

Success Stories contains supportable claims for some of the benefits of DOE's research. For example, the atmospheric fluidized-bed coal combustor developed by DOE allows utilities to efficiently produce electricity from low-grade coal. DOE also documented its claim that DOE-2, a computer software program that helps reduce energy use in buildings, saved almost $2 billion in energy costs for buildings constructed through 1993.

However, we found problems with the analyses supporting the benefits cited for 11 of the 15 cases we reviewed. Although these problems cause us to question the amount of benefits claimed for these cases, substantial benefits may still be attributable to some of these cases. The enclosure to this report summarizes the problems we found with the analyses supporting the 15 cases we reviewed.

As the enclosure shows, the problems we identified in the 15 cases fell into the following four general categories:

-- Math Errors. Two of the case studies were based on analyses containing basic math errors that greatly affected the estimates of benefits. For example, the supporting analysis for the benefits of the carbon dioxide (CO_2) sand fracture production technology--a new process that is expected to increase production from some gas wells--improperly applied the price of natural gas to an incorrect amount of expected increased production. This error resulted in an unrealistic estimate of the increased revenues that could be expected from each well using the new technology. Applying the price of gas to the correct amount of expected increased production from the test wells over their first 7 years of production leads to an estimate of increased revenues of between $216,000 and $294,000 per well--not the $20 million per well cited in Success Stories.[5]

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[4] Because the case studies were not consistently prepared and because we did not select a random sample, we cannot quantitatively generalize from our sample of 15 to the 46 other technologies described in Success Stories.

-- Problems with the supporting economic analysis. Nine of the 15 cases contain estimates of benefits that are based on analyses containing weak economic reasoning, poor assumptions, or other errors. For example, when DOE projected the domestic sales of its integrated gasification combined cycle (a clean coal technology) from 1998 to 2030, it did not discount the sales figures to reflect the time value of money. Using a conservative interest rate, discounting would reduce DOE's claimed benefit from $150 billion to $44 billion. In another example, the supporting analysis for the mud-pulse telemetry project--a well-drilling technology developed by DOE that saves time and money--assumes that the total amount of money the well-drilling industry has spent on this technology equals the amount saved by the industry. This assumption incorrectly implies that every dollar spent on the technology is a savings attributable to the technology. The value of this technology to the industry is the amount of money the industry has saved by using it, rather than the amount of money the industry has spent on it.

-- Weak or indirect link between the stated benefits and DOE's R&D activities. Although DOE claims in Success Stories that it developed the sand fracture technology, the supporting documents provided to us state that the process was developed and patented in Canada and that DOE is currently demonstrating its effectiveness on a number of U.S. wells. In another case, DOE cites energy savings of $5 billion attributable to the use of the flame retention head oil burner technology over the past 15 years, although DOE's contribution was limited to testing and publicizing the technology. Although Success Stories clearly identifies DOE's limited role, the reader could easily be led to believe that the value of DOE's contribution is the estimate of total energy savings from the technology. We do not believe that the total savings resulting from consumers' use of this technology should be linked directly to DOE's activities.

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[5] In this case, DOE also incorrectly assumed the technology would increase production throughout the productive life of each well. However, the supporting documents provided to us by DOE indicate that the scientists and engineers conducting the project are not willing to assume that the wells will continue to produce at increased rates past the first 7 years of the project.

-- Benefits did not result from the technology. In its discussion of the benefits of the AC electric drive train, Success Stories cites a California mandate for electric vehicles that is expected to create a $350 million market in 2003. However, according to an official with the California Air Resources Board, the mandate was developed independently of the AC electric drive train. Although the drive train may help automakers meet the mandate by improving the performance of electric vehicles, it did not result in the mandate. Thus, the potential market created by the mandate cannot be considered a result of the drive train.

REPORT CANNOT BE USED TO ASSESS THE VALUE OF DOE'S APPLIED R&D PROGRAMS

In our opinion, Success Stories cannot be used to assess the effectiveness of DOE's applied R&D programs for two reasons. First, none of the case studies we evaluated discuss how much DOE spent on its R&D efforts supporting the technology. Such information is necessary to determine whether DOE's investment in applied R&D programs is cost-effective. For example, in describing the environmental advantages of the nuclear light-water reactor technology and the savings that will result if the operating licenses of current plants are extended, DOE does not mention that it has spent about $1 billion over the past 10 years on efforts to improve and advance the use of nuclear light-water reactor technology. DOE also does not discuss the environmental downside of nuclear power--the unresolved problem of long-term disposal of the high-level radioactive waste created by the reactors.

Secondly, we believe that the report cannot be used to evaluate DOE's applied R&D programs because it highlights only a small percentage of the projects funded by these programs and describes only what DOE considers to be the most successful of the technologies the Department has supported. The cases summarized in Success Stories are not a representative sample that can be used to evaluate DOE's applied R&D programs overall.

AGENCY COMMENTS

We provided a draft of this report to DOE for its review. In commenting on the draft, DOE officials, including the Acting Assistant Secretary for Policy, acknowledged that our review revealed several errors in the analyses supporting the benefits cited in Success Stories and said DOE would improve the "quality control" over similar reports in the future.

These officials expressed concern that some readers of our report would see our criticism of Success Stories as a general condemnation of DOE's R&D programs. They believe such criticism to be inappropriate given the limited scope of our review. Similarly, they believe that the enclosure to our draft report summarizing the types of problems we found in the analyses supporting the 15 success stories conveys the misleading message that the 11 cases for which we identified problems are "failures," with no benefits. They pointed out that these projects may still have benefits and may still be "successes," although DOE made some errors in analyzing the benefits.

We agree that in several of these cases, the benefits may be substantial. We have added clarifying language to the report to underline that our chart is simply a summary of the problems we identified and that our review was limited to the Success Stories report. We are drawing no conclusions about DOE's R&D programs and, in fact, conclude that the report cannot be used to evaluate the programs overall.

DOE also disagreed with our conclusion that Success Stories is of limited use in evaluating the effectiveness of its applied R&D programs. In this regard, the Acting Assistant Secretary for Policy compared the Department's investment in applied R&D projects to a "high-risk" investment portfolio. According to this official, an investor managing a high-risk portfolio accepts a large percentage of failures in exchange for a few successes with very large returns. Similarly, DOE believes it is entirely appropriate to focus on a few successful projects with large benefits to justify its R&D programs overall.

We continue to believe that any evaluation of DOE's applied R&D programs must consider both the costs and benefits of each project. DOE's applied R&D programs include many high-risk efforts that could lead to a high rate of failure. However, we believe that without comparing costs and benefits, it is impossible to determine whether projects are successes or failures. Moreover, without cost information, it is impossible to determine the rate of return on the federal government's total investment in the programs.

To accomplish our objectives, we interviewed officials within DOE's Office of Science Policy and reviewed documentation they provided. To test the claims of economic impact made in Success Stories, we selected 15 cases that provided a cross section of DOE's applied R&D programs and allowed us to assess the analyses for many of the largest claims of benefits for detailed review. We contacted the officials in the appropriate DOE research program offices who were responsible for the individual projects and obtained and evaluated the supporting documentation provided for each case. We conducted our work from October 1995 through March 1996 in accordance with generally accepted government auditing standards.

We are sending copies of this report to other congressional committees; the Secretary of Energy; and the Director, Office of Management and Budget. We will also make copies available to others upon request. If you have any questions about this report, please call me at (202) 512-3841. Major contributors to this report were Robin Nazzaro, Ronald Stouffer, and Daren Sweeney.

Sincerely yours,

Victor S. Rezendes
Director, Energy, Resources,
and Science Issues

SUMMARY OF GAO'S ANALYSES OF SELECTED TECHNOLOGIES FEATURED IN DOE'S SUCCESS STORIES REPORT

Note: Although these problems cause us to question the amount of benefits claimed for these cases, each may still have substantial benefits.

Technology	Description	Benefits claimed	GAO's analysis				
			Adequate support for all benefits claimed	Inadequate support for benefits claimed[1]			
				Math error	Economic analysis problem	Benefits not directly linked to DOE's role	Technology not directly linked to benefits
Fluorescent lamp electronic ballasts	DOE developed the electronic fluorescent lighting ballast at its Lawrence Berkeley Laboratory in the mid-1970s. The ballast eliminates the flicker and hum of traditional magnetic ballasts and saves energy.	Ballast has improved lighting quality and saved consumers $750 million in energy bills.			●		
Software for building design	DOE developed a software tool, DOE-2, that estimates, on the basis of a building's characteristics, its energy use and cost.	Use of this software accounts for $1.9 billion in energy savings for buildings constructed through 1993.	●				
Nickel metal hydride batteries	DOE is supporting the development of a low-cost, high-performance battery for electric vehicles through the United States Advanced Battery Consortium. This battery would double an electric vehicle's driving range between recharges and significantly increase power.	The mandates for electric vehicles in California and the Northeastern states will create a $350 million market for this battery in 2003.			●		●

Technology	Description	Benefits claimed	GAO's analysis				
			Adequate support for all benefits claimed	Inadequate support for benefits claimed[1]			
				Math error	Economic analysis problem	Benefits not directly linked to DOE's role	Technology not directly linked to benefits
AC electric drive train	Under a cost-shared contract with DOE, Ford Motor Company and General Electric developed a new electric drive train for electric vehicles that run on AC current.	New design will reduce consumers' costs and allow electric vehicles to enter the market sooner. California laws mandating zero-emission vehicles will result in approximately $70 million in electric vehicle sales in 1998, growing to $350 million by the year 2003.		●		●	●
Electrochemical dezincing of steel scrap	DOE has developed an electrochemical method that removes the zinc from steel scrap so that the scrap can be used in steelmaking operations.	Electrochemical method will (1) increase production yields and quality and (2) by the year 2000, will save 50 trillion Btus and reduce raw material imports by at least 75,000 tons of zinc per year, thereby saving $77 million annually.			●		
Integrated gasification combined cycle (IGCC)	IGCC is an advanced coal-burning system that DOE believes will be the power plant of the 21st century.	IGCC technology will (1) reduce sulfur dioxide and nitrous oxide emissions to less than 10 percent of new source performance standards, (2) reduce carbon dioxide emissions by 35 percent to 45 percent, (3) reduce solid wastes by 40 percent to 50 percent, and (4) be less costly to build.			●		

Technology	Description	Benefits claimed	GAO's analysis				
			Adequate support for all benefits claimed	Inadequate support for benefits claimed[1]			
				Math error	Economic analysis problem	Benefits not directly linked to DOE's role	Technology not directly linked to benefits
Photovoltaics	Photovoltaics are devices that convert light into electricity. DOE's photovoltaic program has succeeded in reducing the cost of such electricity from 90 cents per kilowatt hour to 20 cents per kilowatt hour.	$100 million in photovoltaic sales supports or creates 3,800 U.S. jobs.	●				
Mudpulse telemetry	In the 1970s, DOE helped a private company develop an instrument for measuring while drilling that significantly cut the cost and time of drilling oil and gas wells.	Mudpulse telemetry has gained wide acceptance in the drilling industry, and DOE estimates that it has saved the natural gas and oil industry at least $1 billion over the past 20 years.			●		
Carbon dioxide sand fracture production technology	DOE developed, tested, and helped commercialize this technology for stimulating production from natural gas wells. It has been shown to increase production by 200 to 500 percent.	This technology could generate $20 million more revenue over the productive life of some wells.		●	●	●	
Atmospheric fluidized bed coal combustor	DOE helped develop a coal combustor that uses low-polluting coal to produce electricity. According to DOE, every U.S. boiler manufacturer now sells a fluidized bed coal combustor.	Over the last 8 to 10 years, more than $8 billion in domestic sales and $2 billion in foreign sales have been reported. Domestic sales alone translate into more than 250,000 jobs.			●		

Technology	Description	Benefits claimed	GAO's analysis				
			Adequate support for all benefits claimed	Inadequate support for benefits claimed[1]			
				Math error	Economic analysis problem	Benefits not directly linked to DOE's role	Technology not directly linked to benefits
Light-water reactors	DOE has supported nuclear light-water reactor technology, which currently produces about 22 percent of the nation's electricity.	The electricity currently produced by light-water reactors would cost $20 billion per year if produced by conventional power plants. Also, over the past 20 years, nuclear power plants have replaced the equivalent of $400 billion of fossil power, thereby displacing significant amounts of air pollution. Ongoing research is directed at procedures to extend the life of existing nuclear plants. DOE estimates that each plant that is allowed to extend its operating life by 20 years will save about $800 million in replacement costs.			●		
High-energy batteries	DOE's research resulted in the development of high-energy lithium batteries used in security systems, robotics, and medical instruments.	Commercial use of such batteries has accompanied and enabled the explosive growth of the multi-billion-dollar portable electronics industry, including lap-top computers.	●				
Advanced energy-efficient windows	DOE, in a partnership with industry, developed a window that uses low-emissivity coatings to block heat gain or loss. DOE invested $3 million in this technology.	Cumulative consumer energy savings are $1.8 billion. Every major glass and window manufacturer offers low-emissivity products.			●		

Technology	Description	Benefits claimed	GAO's analysis				
			Adequate support for all benefits claimed	Inadequate support for benefits claimed[1]			
				Math error	Economic analysis problem	Benefits not directly linked to DOE's role	Technology not directly linked to benefits
High-efficiency refrigerator compressors	From 1978 through 1980, DOE sponsored a project that resulted in a 44 percent improvement over the compressor technology used in refrigerators at that time.	Use of the improved compressors pioneered by this research saved consumers at least $8 billion in energy costs from 1980 through 1990.	●				
Flame retention head oil burner	In the early 1970s, a DOE field test established the energy conservation benefits of a new flame retention head oil burner. DOE later published its findings in a consumer-oriented information booklet. Within several years, the flame retention head burner dominated the market for new and replacement oil burners.	Consumers' energy cost savings to date from this innovation total more than $5 billion.				●	

(307736)

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HARRIS W. FAWELL, Illinois
CONSTANCE A. MORELLA, Maryland
CURT WELDON, Pennsylvania
DANA ROHRABACHER, California
STEVEN H. SCHIFF, New Mexico
JOE BARTON, Texas
KEN CALVERT, California
BILL BAKER, California
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WILLIAM P. LUTHER, Minnesota

*Ranking Democratic Member

April 17, 1996

The Honorable Charles Bowsher
Comptroller General of the United States
General Accounting Office
Washington, DC

Dear Mr. Bowsher,

I am writing to express my dismay at the obvious methodological errors contained in the April 15, 1996 GAO letter report to Representative Kasich (GAO/RCED 96-120R). Your report takes the Department of Energy to task for the validity of claims for their R&D programs made in a document they produced entitled, Success Stories: the Energy Mission in the Marketplace .

After a review of the DOE report, your letter report to Chairman Kasich, and a face to face meeting between your staff and mine to understand GAO's supporting analysis, I find the conclusions of your report to be unfounded. The report makes incautious statements that are not fully supported by GAO's analysis—ironically, the very charge GAO levels at the Department of Energy. GAO's central claim is that "we found problems with the analyses DOE used to support the benefits cited in 11 out of the 15 cases we reviewed." However, according to your background document and staff interviews with GAO auditors, this statement is misleading and rests upon analytical failures committed not by DOE, but by GAO. Let us look in detail at nine of the cases of alleged faulty analysis.

GAO had no problem with the analyses or benefits claimed by DOE for three of the challenged cases (florescent light ballasts, advanced energy efficient windows, and flame retention heat oil burners). However, GAO felt that an alternative or a longer, more involved analysis should have been offered by DOE in their Success Stories document. Of course, for reasons of brevity, GAO neglects to explain what these alternative analyses would look like in their own report, simply counting these three cases as among those based on "faulty economic analysis". Apparently, you would hold DOE to a much higher standard of transparency in intellectual processes than you hold your own reports.

In another case (nickel metal hydride batteries), GAO felt that since the market for this technology was created by an environmental mandate, it was not fair to claim that the technology was truly a success. Your staff viewed this success as an artificial construct of regulation, though they did concede in an interview with my staff that the market exists none-the-less. Further, GAO made a math error when estimating the price of the battery used to calculate future sales, which caused GAO to question DOE's sales estimates. The error, alas, was with GAO itself, not DOE.

In a fifth case, GAO accepted the calculations offered by DOE for sales of AC Electric Drive Train technology. However, GAO auditors felt that DOE could not claim the technology as a success of their research programs because the technology was developed at General Motors and Chrysler. GAO's source for this assertion was an interview with a staffer for the California Air Quality Control Board who claimed to have spoken to a couple of researchers at GM. In short, GAO relied upon hearsay evidence to repudiate a claim by the Department of Energy. My understanding is that GM and Chrysler both used published reports of DOE-supported R&D to jump-start their own efforts in this field. This fact could be easily verified by interviewing the research teams involved. If this checking had been done, there would, in all likelihood, be no challenge to DOE's claim of benefits.

GAO also challenged the claims by DOE for the Integrated Gasification Combined Cycle success story. However, GAO's only quibble with DOE's analysis was that the final benefits figure was not discounted for the time value of money. GAO's calculation, not offered in the public report to Chairman Kasich, reduces DOE's benefit from $157 billion to a measly $44 billion. Although DOE never claimed the benefits figure to be discounted, GAO still found this case an example of "faulty economic analysis".

In the case of the Atmospheric Fluidized Bed Coal Combustor, GAO's sole complaint is that DOE estimated the jobs created from this technology. Note, no objection was raised to the model used because DOE relied upon the *standard method* developed by the Bureau of Economic Analysis. This method is the standard for developing job figures for any economic sector, industry or innovation. GAO did not assert that the jobs do not actually exist or that the number was in error. However, the GAO Evaluator in Charge personally felt that no job creation claim should have been made. There is no methodologically significant ground offered for this personal judgment; it is simply his opinion which led to this challenge to DOE's claim.

Concerning the de-zincing case study, GAO claims that DOE did not accurately calculate the amount of energy saved from this technology. However, GAO's claims about DOE's calculation were in themselves wrong, because DOE had in fact calculated the figure exactly as GAO would have wished. In addition, GAO's rejection of the DOE claim for success rested upon an auditor's inference that the costs for production of zinc were lower in other countries. However, quick checks with the Commerce Department and the U.S. Geological Survey show that your staff's inference is not correct and, although the U.S. imports the majority of its zinc from Canada, the costs of production there are higher than for zinc produced in the U.S. GAO never attempted to understand the structure of the zinc market and never validated its assumptions with the Department of Commerce and the U.S. Geological Survey. As a result of this factual error, GAO questioned DOE's analysis of import displacement resulting from this technology. However, it was the shoddy market structure analysis done by GAO that was faulty.

Concerning the Mud Pulse Telemetry project, GAO claims that DOE inaccurately calculated benefits flowing from this innovation. However, for such breakthrough technologies, where the benefits are widespread and revolutionary, there are often no means to accurately calculate benefits. Economists and public policy specialists are familiar with the difficulties in estimating the benefits from such innovations. There is not standard, widely-accepted method for calculating the full benefits of such technologies; the first economist to develop such a model will probably win a Nobel. Knowing of these problems, DOE performed a rough estimate and indicated in their Success Stories report that the billion dollar benefit they were claiming was a lower bound number. DOE is now in the process of developing a more detailed estimate of the benefits of this technology and is producing numbers much higher than those claimed in the Success Stories document. Thus, the DOE claim in Success Stories appears at this point (and at the time of publication of the GAO report) to be an understatement of the true benefits of this technology. Further, GAO itself seems to have misunderstood the analytical method used by DOE in reaching their first estimate. Never-the-less, this was counted as an example of "faulty economic analysis."

In nine of the eleven cases challenged by you, your own work shows errors, mistakes, misstatements, shoddy analysis or simple differences of opinion masquerading as methodologically sound criticisms. Unfortunately, because the report done by GAO does not offer up the analysis and assumptions and factual basis for your conclusions, it is impossible for the public or Members to judge the soundness of your work. Instead, they will simply face GAO's bold assertions, stated as cold-blooded facts, that DOE's analysis was faulty and that DOE's claims of success often lack an adequate analytical basis. The picture left by your report is that DOE is either incompetent or lying and that the successes claimed are actually failures. The truth is that your evaluation is unbalanced, incomplete, and often dead wrong, and even using your own preferred methods, most of the challenged cases would still count as "successes".

On the basis of my review of the letter report and the background documents, I submit that GAO lacks the quality control required of a reputable Congressional support agency. If my staff can find this number of errors in twenty-four hours on a work product that your staff spent seven months on, then you have a system that doesn't work. I would recommend that GAO develop an appropriate peer review system to fully vet your claims and analysis. Further, I would submit that the emphasis on a punchy "bottom-line" statement to put in the front of your reports has led in recent years to a growing tendency towards overstatement or mischaracterization of findings. This, coupled with an in-house decision to exclude detailed analytical work in your reports, has contributed to distortions of those "findings" and an increasing politicization of GAO reports that endangers the long-term support for your institution

The job of GAO is a critical one and your credibility should not be squandered lightly in an effort to make your message simpler and more media friendly. I would be happy to discuss this further with you at any point.

Sincerely,

George E. Brown

George E. Brown Jr.
Ranking Democratic Member

cc:
The Honorable John Kasich
The Honorable Martin Olav Sabo
The Honorable Ron Packard
The Honorable Vic Fazio
The Honorable John T. Myers
The Honorable Tom Bevill
The Honorable Ralph Regula
The Honorable Sidney Yates
The Honorable Robert Walker

Assistant Comptroller General
of the United States

Washington, D.C. 20548

B-272006

May 13, 1996

The Honorable George E. Brown, Jr.
House of Representatives

Dear Mr. Brown,

This responds to your April 17, 1996, letter to the Comptroller General expressing concerns about our April 15, 1996, report to the Chairman, House Committee on the Budget, entitled DOE's Success Stories Report (GAO/RCED-96-120R). In your letter, you state that our report, which examined a number of the case studies included in the Department of Energy's report Success Stories: the Energy Mission in the Marketplace, contains methodological errors and unfounded conclusions.

In view of the seriousness of the concerns you have expressed about the manner in which this work was performed, the report and the work on which it is based have been reviewed by GAO's Assistant Comptroller General for Policy, who was not involved in the assignment.

On the basis of this review, we believe that our work supports our conclusions about each case study we reviewed, and that our work was performed with due professional care consistent with generally accepted government auditing standards; GAO's standards, policies, and procedures; and the standards provided by the Office of Management and Budget (OMB) for evaluating the costs and benefits of federal activities. Enclosure I provides a point-by-point response to your specific concerns about our analysis of each of the nine case studies mentioned in your letter.

OBJECTIVES OF OUR REVIEW

Our objectives were to determine whether (1) DOE provided reasonable support that the benefits cited in the report resulted from DOE's investment and (2) Success Stories can be used to assess the overall value of DOE's applied research and development (R&D) programs.

METHODOLOGY APPLIED

Consistent with these objectives, we determined whether DOE could document each claim and assessed its analyses and studies supporting these claims. In some instances, DOE's analyses or studies were based on multiple assumptions or reached more than one conclusion. In such instances, we sought support for each assumption or conclusion. However, we accepted DOE's estimates when they involved models that calculated the energy savings or other benefits of the technology. Performing an evaluation of these models was beyond the scope of our work. Our standard of evidence for support was written documentation provided by DOE. We requested oral explanations for clarification or in those instances in which agency officials, following repeated requests, did not provide written documentation.

Our analysis is entirely consistent with the standards of analysis put forward by OMB in Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," which must be adhered to in all analyses submitted to OMB in support of legislative and budget programs. This circular provides guidance on the use of incremental benefits and costs, appropriate use of discounting, and treatment of interactive effects. We applied all of these in our analysis.

BASES FOR OUR FINDINGS AND CONCLUSIONS

As we stated in our report, to accomplish the first objective we selected 15 of the case studies in Success Stories for detailed review. We found several types of problems or weaknesses in the documentation DOE provided us as support for the benefits claimed in the case studies. When the supporting documentation identified multiple assumptions or conclusions, the presence of any single weakness in these assumptions or conclusions was reflected in the table enclosed with our report. The background document mentioned in your letter was used to brief DOE and your staff and was not enclosed with our report. The interviews cited in the background document, such as an interview with an official of the California Air Resources Board, took place primarily when we sought clarification because of insufficient information. Our report makes clear that (1) the identification of a problem or weakness in a research project does not mean the project is unsuccessful and (2) although these problems cause us to question the amount of benefits claimed, substantial benefits may still be attributable to some of the projects.

In a meeting held on April 10, 1996, to obtain DOE's comments on a draft of our report, DOE officials expressed concern that some readers of our report would see it as a general condemnation of DOE's R&D programs. They also stated that the enclosure to our draft report summarizing the types of problems we found conveyed the message that the cases we identified as having problems were failures, with no benefits. However, DOE officials, including the Acting Assistant Secretary for Policy, acknowledged that our review revealed several errors in the analysis supporting the benefits cited in Success Stories and said that the Department intends to upgrade its quality control over such reports in the future.

Regarding our conclusion that Success Stories cannot be used to assess the overall value of DOE's applied R&D programs, we note that, in a meeting held on November 1, 1995, a Special Assistant in DOE's Office of the Secretary characterized Success Stories as a hastily prepared document meant to counteract criticism stating that DOE's applied R&D programs have produced few successes. Success Stories presented the benefits as anecdotes illustrating some of the positive outcomes of DOE's applied energy R&D programs rather than as a precise estimate of the net economic gains to society. As we stated in our report, we believe that Success Stories accomplishes that objective.

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In summary, we continue to stand behind our report, which found weaknesses in the support DOE used to document the claims of economic benefit made in many of the Success Stories case studies we examined. These weaknesses cause us to question the amount of benefits claimed for these cases--even though we recognize that some of these projects may still be considered "successes." Our report fairly concludes that reports like Success Stories are not very useful for evaluating DOE's overall applied R&D programs, regardless of how well they are prepared, because they (1) do not consider overall program costs and (2) look only at a very small percentage of the projects in DOE's applied R&D programs. In addition, we note that the benefits cited in Success Stories do not necessarily represent the net economic benefits to society. Rather, as we stated in our report, a comprehensive analysis of all of DOE's R&D programs should rigorously consider all of the costs and benefits. We also believe that such a review should use widely accepted economic guidelines such as those provided by OMB. In addition, consistent with our previous work in this area, we believe that DOE needs to evaluate whether the private sector could or should be conducting this research.

We hope that this information responds to the concerns you expressed in your letter. I would be glad to meet with you if you have any further questions.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General
for Planning and Reporting

Enclosure

GAO'S RESPONSES TO SPECIFIC CONCERNS

The following are GAO's responses to the specific concerns you expressed about the technologies we examined in our review of DOE's Success Stories report (GAO/RCED-96-120R, Apr. 15, 1996).

1. Fluorescent electronic light ballast, low-emissivity windows, flame retention head oil burner. Your letter states that we "had no problem" with DOE's analyses or benefits in these cases. This portrayal of our position is not accurate. Our report concludes that DOE's claims about these case studies were based on inadequate support. In the case studies on the ballast and on low-emissivity windows, DOE did not include an analysis of the higher cost of the technology to the consumer. For example, DOE did not consider that a fluorescent electronic light ballast costs a consumer $8 more than the conventional magnetic ballast. When this price premium is considered, consumers spent $52 million more for fluorescent lamp electronic ballasts than they saved in energy bills during the period DOE examined (January 1988 to April 1995).

In the case study on the flame retention head oil burner, we were concerned about the implied linkage between DOE's investment in the project and the $5 billion in energy savings DOE attributed to the technology. As Success Stories reports, DOE's role was limited to testing and publicizing the technology, which subsequently captured the market following the energy crisis in the 1970s. According to a DOE official, DOE's efforts accelerated the commercialization of this technology by 5 to 6 years. Thus, we believe a more reasonable estimate of the benefits of DOE's investment in this project would be based on the savings attributable to the early introduction of this product. DOE later claimed that this technology might not have been commercialized without its efforts, but failed to provide convincing support for this claim.

Your letter also states that we believe DOE should have used "an alternative or a longer, more involved analysis" to address these problems. For these three cases, we believe that adequate support could have been provided without a longer, more involved analysis. For example, although the value of the energy savings may exceed the ballast's higher price over a longer period of time, we believe that DOE should have included the higher price in its calculation. Such an analysis would not have required much additional work because DOE had this information in hand.

2. Nickel metal hydride battery. Your letter states that although we critique DOE's use of an environmental mandate to illustrate the success of the battery, we acknowledged in a meeting with your staff that "the market exists none-the-less." We believe that the California mandate for electric vehicles created a potential market

for all technologies for these vehicles, not just the nickel metal hydride battery. Also, a potential market does not mean that this battery or any technology will be technically feasible or economically viable. These two points form the basis for our conclusion that DOE did not adequately support the benefits claimed.

Industry analysts also question whether this battery will ever be competitive in an open market that includes gas-powered cars. In a recent report, we said that at the price projected for the battery, large subsidies will be needed to sell the electric vehicles that use it.[1] Although research has developed a battery that can meet mid-term performance goals, many industry analysts question whether the battery will enable electric vehicles to perform well enough to have wide appeal to large numbers of consumers. It remains unclear whether the feasibility of a long-term battery--one that can compete in performance and cost with gas-powered vehicles--will be demonstrated.

We did not make a math error in estimating the price of the battery DOE used to calculate future sales. DOE estimated the price at $7,500 per battery. Our concerns were that this price (1) does not reflect the cost of the battery at today's level of technology ($12,000), (2) exceeds the Advanced Battery Consortium's mid-term goal by $3,000, and (3) would require large subsidies to make electric vehicles marketable, according to industry experts.

3. AC electric drive train. Your letter states that "GAO relied upon hearsay evidence" from the California Air Resources Board to repudiate DOE's claim. Our conclusion was not based on the conversation referred to in your letter. During our review, a DOE official told us that General Motors-Delco and Chrysler-Westinghouse had independently developed AC electric drive trains, leading us to question whether DOE could take sole credit for the projected benefits of this technology. DOE said that its research had spurred General Motors and Chrysler to develop their own technologies. However, DOE provided no evidence to document its claim. As a result, we concluded that the technology was not directly linked to the benefits that DOE cited. The purpose of our conversation with an official of the California Air Resources Board was to learn whether the board had created its electric vehicle mandate in response to the development of the AC electric drive train, not why GM and Chrysler had developed their own drive trains.

4. Integrated gasification combined cycle (IGCC). Your letter states that our only criticism of DOE's analysis was that it neglected to discount DOE's claimed benefit.

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[1] Electric Vehicles: Efforts to Complete Advanced Battery Development Will Require More Time and Funding (GAO/RCED-95-234, Aug. 17, 1995).

We believe this is an important weakness in the supporting analysis. An economic analysis that projects income from sales far into the future should account for the time value of money. As we state in our report, discounting can have a dramatic effect on the analysis. For example, the conservative rate we used (6.33 percent) reduced the value of the benefit claimed for this technology by 71 percent, or about $106 billion. Although DOE did not state in Success Stories that it had discounted its number, we believe it should have employed this common economic technique. Moreover, DOE appears to have recognized the importance of discounting in another case describing the benefits of the fluorescent electronic light ballast.

Your letter also suggests that we downplayed the importance of the $44 billion revised sales estimate. Our analysis was focused solely on arriving at a sales figure that reflected the time value of money. Furthermore, we note that the $44 billion in projected IGCC sales by domestic manufacturers may exceed the net economic gain from this technology. For example, DOE did not compare its sales estimate to the sales of competing technologies that would have occurred if IGCC had not been developed. OMB Circular A-94 suggests that a benefit-cost analysis should identify the extent to which a policy promotes substitutes for activities of a similar nature that would occur without the policy.

5. Atmospheric fluidized bed coal combustor. Your letter identified a problem with GAO's assessment of the DOE estimate of jobs created as a result of this technology. In fact, our concern was focused on DOE's lack of adherence to a rigorous method of calculating the technology's net impact on the job market. The basis for our conclusion that this technology did not necessarily result in an increase of 250,000 jobs is the guidance provided by OMB Circular A-94, which, as mentioned above, states that an analysis should identify the extent to which a policy promotes substitutes for similar activities that would occur without the policy. Because replacement technologies could have resulted in just as many jobs, the net impact on jobs is uncertain.

6. Electrochemical dezincing of steel scrap. Your letter states that we improperly based our criticism of DOE's claim of success on an inference that production costs were lower in other countries. It also states that we did not accurately calculate the energy that will be saved by this technology.

Regarding our critique of DOE's claim of success, our conclusion was based on the fact that DOE could not support its assertion in Success Stories that all zinc produced from steel scrap would displace imported zinc. In our review, we learned that over two-thirds of the zinc consumed in the United States is imported. This figure suggests that imported zinc is at least competitive on price and other terms with domestically produced zinc. Even if the new process allows zinc to be produced at a lower cost than the existing domestic or imported sources, there is no reason to believe that the new production would displace only imports.

Your letter further notes that investigations by your staff revealed that Canada--the largest exporter of zinc to the United States--produces zinc at a higher price than domestic producers. We believe that Canada's position as the largest exporter of zinc to the United States indicates that its prices and other terms must be competitive with those of other suppliers, irrespective of production costs.

As to the amount of energy that will be saved by this technology, our background document, which was shared with DOE throughout our review, questioned whether DOE had made consistent assumptions in its analysis of the energy savings. Upon further review, we agree that DOE's assumptions were consistent. However, it is important to note that this issue was not included in our report, nor did it form the basis for our conclusion that DOE's supporting analysis was weak.

7. Mud pulse telemetry. Your letter states that there are "no means to accurately calculate benefits" for such "breakthrough technologies." You further question our critique of the supporting analysis for this case, stating that the technology is an obvious success. Although it is clear that this technology has cut costs for the oil and gas drilling industries, the basis for the conclusion in our report is that DOE used a weak methodology to calculate the cited benefits. The supporting documentation for the benefits claimed for this technology states that DOE used the cumulative sales of the mud pulse telemetry service to determine how much the technology has saved the oil and gas drilling industry. As we stated in our report, a better measure of the value of this technology is the amount of money industry has saved using it; that is, the difference between what the industry has spent on the technology and what it would have spent on the next best process. In responding to our initial findings, DOE justified the cited benefits by assuming that the technology's benefit equals 8 percent of the drilling industry's cumulative sales. DOE provided no support for this assumption.

(307744)

Energy Choices in a Competitive Era

The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix

PREPARED FOR
Center for Energy and
Economic Development

PREPARED BY
Resource Data
International, Inc.

Energy Choices in a Competitive Era

The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix

Center for Energy and Economic Development

The Center for Energy and Economic Development (CEED) was formed in 1992 to educate the public and policymakers about new economic, technological, and scientific research relating to the energy resources employed in the generation of electricity. Through its research, CEED has shown that low cost energy results in economic development, competitiveness, and rising standards of living. With offices across the country, CEED is working at the regional, state, and local levels to ensure that sources of electricity generation employ the lowest cost technologies and resources in an environmentally compatible manner.

Resource Data International, Inc.

This study was prepared for CEED by Resource Data International, Inc. (RDI). Since 1981, RDI has been recognized as the industry leader electric power consulting and market information in the USA. RDI's client base consists of the world's largest energy resource companies, electric utilities, financial institutions, railroads and industry consultants. RDI's staff of energy economists and energy professionals provide a broad range of consulting services including strategic planning, acquisition support, market analysis, forecasting and litigation support. RDI's COALdat® and POWERdat® databases have provided reliable desktop market and competitor information to the industry for the past fourteen years. RDI authors monthly market columns in *Public Utilities Fortnightly* magazine.

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FOR MORE INFORMATION

Contact CEED with any questions regarding this study. Copies of RDI's levelized cost model in the Excel™ 5.0 format are also available from CEED at a cost of $50.00 per disk. CEED is a non-profit organization.

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April, 1995

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Energy Choices in a Competitive Era

The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix

April, 1995

SUMMARY OF KEY FINDINGS

Under current levels of tax incentives and regulatory support, renewable energy (excluding hydro technologies) is projected to grow from its current 2% of all U.S. electricity generation to 4% by 2010.

Such an increase in market share will occur at a cost of about $52 billion (in 1995 $) above today's most competitive power alternatives.

With open and direct competition in electricity, generation from renewable energy could shrink to just 1% of U.S. electricity in 2010.

Even with the imposition of exceptionally aggressive subsidies from public and private sectors, renewable energy would provide a maximum of just 11% of the nation's electricity by 2010.

Such an ambitious increase would cost taxpayers, consumers and/or utilities about $203 billion (in 1995 $) in subsidies between now and 2010.

All renewable resources have technological or logistical obstacles that limit their ability to produce and provide reliable electricity to the grid – obstacles that cannot be overcome, even through the use of subsidies.

Approximately 71% of non-hydro renewable generation serving the grid currently comes from combustion technologies--not wind, solar or geothermal processes.

Outside California, nearly all existing renewable generation serving the grid comes from combustion technologies.

All electric generation technologies, including renewables, present adverse environmental impacts.

Because renewables and natural gas occupy similar dispatch positions, gains in generation share by renewables will tend to displace growth in natural gas generation, and similarly, losses in renewables will tend to go to natural gas.

Despite government incentives and private sector subsidies, renewable resources cannot replace fossil fuels in the nation's generation mix.

Coal will remain the baseload fuel of choice, supplying more than half of all electricity generation in 2010, even assuming aggressive subsidies for renewables.

Center for Energy and Economic Development

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never realized begin to terminate, especially in California. Solar thermal, biomass, and geothermal will be the hardest hit, although some wind projects will also face difficulty. The national implications are apparent given that over 90% of the nation's solar, geothermal, and wind capacity is installed in California.

In response to the Public Utility Regulatory Act of 1978 (PURPA) and to the dramatic upsurge in oil and natural gas prices in the late 1970s and early 1980s, the renewables industry grew rapidly, with capacity additions peaking in the mid-1980s. However, as these new units were coming on line, oil and gas prices fell precipitously, resulting in a radical drop in renewable capacity additions by the early 1990s.

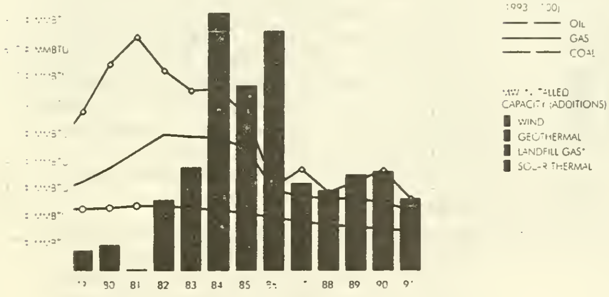
FUTURE GENERATION MIX SCENARIOS

Against this backdrop, public support for renewable resources persists for energy security and perceived environmental reasons. While the EPAct created barriers for further growth (and even re-licensing) of hydroelectric projects, it provides investment and production tax incentives for electricity generated from wind, geothermal, solar, and some types of biomass. This study examines the costs, capabilities, and feasibility of the various renewable energy technologies (excluding hydro), as well as state-of-the-art coal and natural gas technologies, and projects the future U.S. generation mix under three scenarios: (1) Base Case; (2) Full and Open Competition; and (3) Subsidy Intensification.

The results of this analysis show renewable technologies providing just under 3% of the U.S. generation mix by the year 2000 and about 4% by 2010, according to the Base Case

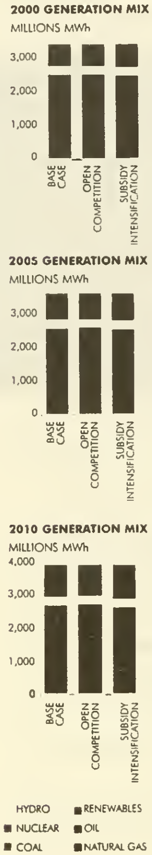
RENEWABLE CAPACITY ADDITIONS VS. DELIVERED FUEL PRICES

1979-1991



scenario. Coal continues to drive the electric generation sector as the foundation of the country's baseload capacity at 54% and 53%, respectively.

ELECTRIC GENERATION FORECAST UNDER THREE SCENARIOS



SOURCE RDI 1995

Because renewable energy projects are not cost competitive, a Full and Open Competition scenario predicts a dramatic reduction of non-waste derived renewable energy generation by the year 2000, resulting in economic failure under 1980s vintage contracts in California and the inability of proposed new plants to win power sales agreements or secure financing. Waste-derived renewables continue to operate and grow only as an alternative to the costs of landfilling, open burning, and other waste disposal options.

However, the most telling results occur under a Subsidy Intensification scenario which posits a 50% subsidization of renewables production costs -- bringing average levelized costs in line with today's most competitive power alternatives. Even with this level of subsidization, electric generation from renewables garners only a 4% share of generation by 2000 and 11% by 2010. At the end of the forecast period, coal maintains its key role as the baseload fuel of choice at 51% of the mix, although natural gas falls to 11%, down from 18% under the Base Case scenario.

Therein lies an important finding of this study–that renewable energy sources stand to gain at the expense of natural gas more than any other competing technology. The reasons are many, but include the following: 1) renewables and natural gas play similar roles in the dispatch order; 2) renewables and natural gas will compete directly for small to mid-sized generation additions; and 3) coal will garner over half of all new generation, first through increased capacity utilization at existing plants and then through the construction of additional baseload projects which provide reliability and economies of scale.

TECHNOLOGY REVIEW

Contrary to popular belief, electric generation technologies are not always interchangeable, since they exhibit important distinctions between capability, resource availability, locational feasibility, and cost. Even within the category of renewable energy technologies, important differences persist. Demarcations exist between technologies that are combustion and

COMBUSTION TECHNOLOGY OVERVIEW

LANDFILL GAS (LFG)

In addition to direct combustion, garbage can also serve as an alternative energy source in a gaseous form. Once a landfill becomes compacted and all aerobic bacteria (i.e., those requiring oxygen) disappear, anaerobic bacteria begin to proliferate. Over the course of anywhere from 10 to 100 years these bacteria produce quantities of methane and carbon dioxide (CO_2) gases, in addition to other trace elements, that must be vented and either flared-off or released into the atmosphere. Recognizing a potential resource, a number of landfills now recover these landfill gases (LFG) for electricity generation or resale into gas markets. In 1991, fully two-thirds of all recovery projects generated electricity from 377 megawatts of capacity.

BIOMASS

Installed U.S. generating capacity based on biomass fuels stood at 7,415 megawatts in 1992, with more than 81% of that figure consisting of non-utility generation from wood and lumber industry residues. In fact, biomass is the largest of all grid-connected renewable energy sources, representing almost half of all installed U.S. renewable capacity (not including traditional hydroelectric). In many senses, biomass is hardly exotic or even an "emerging" technology. Biomass boilers are not very different from coal boilers, and the idea of burning agricultural waste is not new.

What is radical, however, is the concept of cultivating energy crops, and even energy forests, for the primary purpose of fueling boilers. Although the Energy Policy Act of 1992 (EPAct) provides a 1.5¢ per kilowatt hour production tax credit to the technology, costs remain high and there are currently no plants in commercial operation. Siting difficulties and land requirements add to high costs in preventing development. One estimate holds that 12% of the country's farmland would be required to provide 10% of the nation's electricity from such power plants.

MUNICIPAL SOLID WASTE (MSW)

The Environmental Protection Agency (EPA) defines municipal solid waste (MSW) as residential and non-process industrial wastes, excluding industrial process wastes, hazardous wastes, municipal sludge, and construction or demolition waste. The United States generates over 200 million tons of MSW every year, with 84% of that volume consisting of organic material and 16% consisting of inorganic material, such as glass and metals. Residential waste accounts for between 55% and 65% of annual volume. Just less than two-thirds of all MSW is disposed of in landfills, with approximately 20% recycled and more than 17% incinerated.

While some parts of the public support MSW as an alternative to landfills, others decry the environmental impacts of incinerating garbage. Indeed, emissions of heavy metals and other toxic elements are much higher from the 2,300 megawatts of existing MSW plants than from any other combustion technology. Nevertheless, stricter EPA landfill regulations are increasing the cost of landfills with the effect of comparatively improving MSW economics.

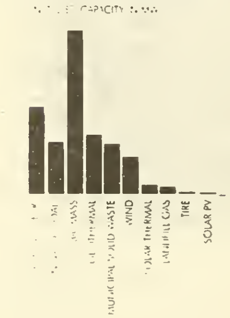
non-combustion, waste-derived and naturally occurring, intermittent and continuous, and land intensive and non-intensive. However, the renewable energy technologies considered in this study have all developed to the point of commercial application.

CAPABILITY

The essence of an electric generation technology may be summed up in a characterization of its capability. Capability in this study is defined as the ability to generate electricity based on generating capacity and availability. In other words, capability determines the extent to which a utility can rely on the technology to meet electricity demand.

At the most basic level, generating capacity determines the amount of electricity that a plant can generate at any one time. Renewables vary in this regard from micro wind, solar, and landfill gas sites of less than one megawatt to about 150 megawatts for the largest biomass, solar, and geothermal plants. New wind farms are also generally limited to 150 megawatts or less, although the largest farm in the world, Tehachapi in California, exceeds 600 megawatts. Limitations on size result from both technological optimization and limitation of the available energy resources. By comparison, U.S. coal plants average 706 megawatts and range to over 3,000 megawatts.

U.S. INSTALLED RENEWABLE ENERGY CAPACITY VS. CAPACITY OF ONE NUCLEAR & ONE COAL-FIRED PLANT



The ability of a utility to draw on generating capacity depends on the availability of the plant. Combustion technologies, such as coal, natural gas, biomass, municipal solid waste (MSW), and landfill gas (LFG), in addition to the non-combustion geothermal and nuclear technologies, present a high level of availability dependent only on planned and unplanned maintenance outages.

One indicator of availability is a plant's capacity utilization rate, which is a percentage of actual annual generation versus annual potential generation based on capacity. In this regard, new coal plants typically achieve capacity utilization in the range of 75-85% due to consistent fuel supply and relatively high availability, while LFG plants fare much worse as the result of unplanned outages that may average 51 weeks. Biomass agricultural waste plants may also experience somewhat lower capacity factors due to the seasonality of certain fuel stocks. Non-combustion technologies such as hydroelectric, solar, and

NON-COMBUSTION TECHNOLOGY OVERVIEW

WIND POWER

The United States is the world's largest producer of electricity generated from wind turbines, with installed capacity totaling 1,725 megawatts as of 1995. Although more than 90% of that capacity is located in California, utilities in six other states currently operate pilot projects. The further spread of wind power is limited geographically because the vast majority of the country's major wind systems are located in California and the Great Plains. Other limiting factors include the intermittent nature of wind, which results in a typical annual capacity utilization of 30%, and the land area required for siting wind farms. Avian mortality has also been cited as a problem, with preliminary studies finding hundreds of red tail hawks and dozens of golden eagles killed in turbine blades every year at just one wind farm in California.

SOLAR THERMAL

There are three well-developed solar-thermal technologies available today that can transfer solar energy into turbine-based electrical generation, including parabolic trough, parabolic dish and central receiver. All of these technologies rely on four system components: receiver, collector, converter, and transport/storage. Like wind, solar thermal technologies provide intermittent availability and are limited by resource availability to the Southwest and California. Although 354 megawatts of capacity are operating in California today, unfavorable energy market economics make development of new projects unlikely through the end of the century.

SOLAR PHOTOVOLTAIC

In 1994, over 400 utility sponsored Photovoltaic (Pv) sites produced close to 14 megawatts of capacity for the grid. While most of these utility projects are very small (less than 0.001 megawatts) and non-cost-effective in comparison to traditional generating technologies, industry specialists feel that Pv economics may someday be pushed over the threshold into market viability. This optimism is driven by the increasing production of consumer Pv cells (e.g., those used in watches and calculators) and a growing demand for stand-alone Pv systems in developing countries.

Nevertheless, costs currently remain high for central generation from Pv technologies. The most promising area for the technology lies in remote applications, where the cost of installing or upgrading distribution lines or substations may be more expensive than installing a Pv generator at a new demand center. In addition to economic limitations, solar Pv is limited by intermittent availability.

GEOTHERMAL

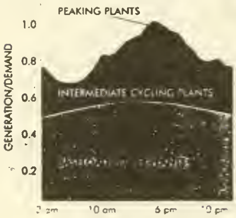
Four geothermal technologies are commercially available today: Dry Steam, Single Flash, Double Flash, and Binary Cycle. Dry Steam extracts naturally occurring steam from a well and runs it directly through a turbine. Flash plants pull hot water from a well into a separator tank where lower pressure allows a portion of the water to "flash" into steam and run through a turbine. Binary Cycle technologies run hydrothermal fluids in one loop and a power fluid (isobutane or ammonia) in another. These two loops align in a heat exchanger where the power fluid is vaporized and then run through a turbine.

Geothermal plants have proven a high availability, reaching annual capacity utilization beyond 90%. However, as with the other naturally occurring renewable energy sources, geothermal is limited by resource availability. California, Nevada, Utah, and Oregon possess almost all economically recoverable U.S. geothermal reserves, although pockets exist in other western states. Of the 2,700 megawatts of U.S. operating capacity, 90% are located wind depend on natural forces to provide their energy and therefore experience lower levels of availability. Hydroelectric generation takes place primarily in the Spring when water is plentiful, while lower levels of generation occur in the Fall and Winter when water is more scarce. To some extent, utilities can control availability by storing water in reservoirs. Conversely, storage technologies for solar and wind generation are not yet commercially available. Utilities employ intermittent wind and solar generation according to seasonal and even daily statistical probabilities, but cannot predict availability with absolute certainty. Capacity utilization for these technologies falls below 30%.

DISPATCHABILITY

The ability to control and draw on capacity to meet different levels of demand is central to electric utility economics. Throughout the day, utilities experience a relatively constant level of demand called "baseload" and a moderately fluctuating level called "intermediate." Sharp spikes in demand are called "peaks" and can occur when a large number of customers demand power simultaneously. A typical demand peak, for example, occurs when everyone turns on their air conditioners on a hot summer afternoon.

A TYPICAL DISPATCH PROFILE



Utilities dispatch power plants at these different levels according to capability and cost. Plants assigned to baseload must be capable of continuously providing large amounts of electricity at a low operating cost, while plants assigned to intermediate load must be able to handle moderate fluctuations and are allowed a somewhat higher operating cost. Peaking plants must provide generation on very short notice, with less emphasis placed on cost. Therefore, coal and nuclear plants have historically served as baseload plants, not only because of their size, reliability, and low operating costs, but also because these technologies work best when operated at a continuously high level. Natural gas and oil serve as peaking units because of their higher variable costs and ability to increase generation quickly. Intermediate units consist primarily of larger gas plants with lower variable costs, as well as some older coal plants with moderate operating costs.

While renewable combustion technologies and geothermal may fit into this scheme, a special niche must be found for intermittent technologies. Solar and wind can neither be relied upon to provide large amounts of continuous generation for baseload nor can they be called upon to provide immediate generation for peaking. To adapt to these resources, utilities use intermediate or peaking generation to fill-in periods of low solar or wind generation. In a similar vein, some biomass plants provide generation seasonally, displacing traditional baseload or intermediate capacity when agricultural waste fuelstocks are plentiful.

Hydroelectric acts in the same way, with large displacements of coal and nuclear generation occurring in the Spring. Yet, this seasonal displacement of coal and nuclear plants is supported by the extremely low production costs of hydroelectric, while higher costs for solar, wind, and biomass generation provide little justification.

ECONOMICS

Production costs work in concert with capability to determine a plant's position in the dispatch order. If available, the least cost plants run first and the highest cost plants run last. This study compared the levelized production costs of the various renewable technologies, as well as coal and natural gas, to determine the competitive positioning of the technologies capable of providing new generating capacity.

There are three key factors that enter into the calculation of the levelized costs for each competing technology: 1) the cost of constructing and running the plant; 2) the projected cost of the fuel; and 3) the capacity utilization rate. RDI relied on EPRI's 1993 Technical Assessment Guide (TAG), in addition to vendor interviews, to determine the most likely plant designs and capital costs available today. For the cost of fossil fuels, RDI relied on its most recent regional fuel price forecasts as published in its *1995 Outlook for Coal and Competing Fuels.* Capacity utilization for fossil and combustion-based renewables plants is based upon the assumption that new plants will operate at the high end of the capacity currently attained by the newest state-of-the-art power plants for each technology. The following is a list of designs and operating parameters used in the base case cost analysis for each technology.

In order to compare the economics of various generating technologies, it is necessary to spread the capital cost over the plant's life and to add to this the projected ongoing operating and maintenance costs such as fuel and labor. In the chart below, the renewables subsidies provided by the EPAct have been factored into the levelized costs of these technologies, thus lowering their effective production costs.

TRADITIONAL TECHNOLOGIES

- Pulverized coal (PC) plant with wet flue gas desulfurization located in the Southeast. One 400 megawatt unit burning bituminous coal, with an annual capacity utilization of 80%.
- Atmospheric fluidized bed combustion (AFBC) coal plant located anywhere in the U.S. One 200 megawatt unit burning bituminous coal, with an annual capacity utilization of 70%.
- Natural gas combined cycle turbine (CCT) unit located anywhere in the U.S. Capacity of 225 megawatts running at a 65% annual capacity utilization.

RENEWABLE TECHNOLOGIES

- Wind variable speed 0.2 megawatt turbine located in a Class 4 wind regime. Technology is based on the NREL Concept 1 with control electronics and advanced design airfoils placed on a 50 meter tower. Annual capacity utilization assumed at 29%.
- Biomass fluidized bed combustor burning wood and located in the West. One 50 megawatt unit operating at an annual capacity utilization of 70%.
- Waste-to-energy (WTE) MSW mass burn plant located in the West. 40 megawatts operating at an annual capacity utilization of 70%.
- Geothermal double flash plant located in the West. 1 to 25 megawatt unit operating at an annual capacity utilization of 90%.
- Solar flat plate Pv located in the West. 50 megawatt capacity.
- Solar thermal parabolic trough located in the West. 80 megawatt capacity operating at a 40% capacity utilization.

Sensitivities were examined for financing assumptions, regionality and capacity factors. In the end, the analysis found that coal technologies are consistently the least-cost generating option. With delivered fuel prices declining by 40% to 50% in real terms between 1983 and 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas. At a levelized production cost of 3.3¢ to 4.4¢ per kilowatt hour under

LEVELIZED PRODUCTION COST COMPARISON, BASE CASE SCENARIO

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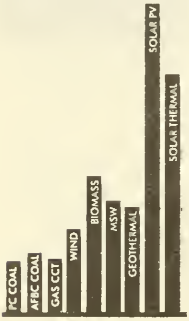


various discount rate assumptions, state-of-the-art coal PC boilers lead the list of new generating options, followed by AFBC coal plants at 3.9¢ to 5.2¢ per kilowatt hour. Natural gas CCT ranges in cost under these scenarios from 4.1¢ to 4.5¢. Renewables (including their subsidies) with the most promise include geothermal units with levelized costs ranging from 6.4¢ to 8.9¢ per kilowatt hour, wind at 5.2¢ to 8.7¢, and MSW from 6.9¢ to 11.9¢.

Cost estimates also varied regionally, with pulverized coal under the Base Case discount rate assumptions ranging from 4.2¢ per kilowatt hour in New England to 3.9¢ per kilowatt hour in the the South Atlantic. Natural gas combined cycle plants range from 5.0¢ in the South Atlantic region to 4.0¢ in the West South Central, and biomass from residue ranges from 9.3¢ in New England to 8.3¢ in the South Atlantic. In the end, a general analysis of the costs and capabilities of each energy resource may serve to educate, but a final decision about energy choices cannot be made without assessing the specific resources and projects in question.

With delivered fuel prices declining by 40% to 50% in real terms from 1983 to 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas.

In order to assess the costs associated with the anticipated growth in renewable electricity generation–that is, electricity generated for the grid–the study examined the implications of both the Base Case and the Subsidy Intensification scenarios:

The Base Case scenario projects that total non-hydro generation from renewables will grow from 73 billion kilowatt hours (BkWh) in 1995 to 180 BkWh in 2010. At today's differential between the levelized cost of the most competitive generation and the projected mix of renewables, the cumulative "above market" cost of this generation between 1995 and 2010 will be $52 billion (1995$).

The Subsidy Intensification scenario posits a 50% subsidization of renewable energy. Under this extremely aggressive scenario, renewables generation grows from 75 BkWh in 1995 to 450 BkWh in 2010. For comparison, this level of generation is roughly one-fourth of today's coal-fired generation, three-fourths of today's nuclear generation or 110% of today's gas generation. Using current levelized costs as a basis of comparison, to achieve this level of generation the cumulative subsidies would total $203 billion (1995$) between now and 2010.

LOCATION

Different regions of the United States are endowed with different energy resources. The West enjoys ample solar radiation, wind, and geothermal resources, while the East enjoys abundant biomass resources. Natural gas and oil are concentrated in the Gulf of Mexico and Alaska, and coal reserves are situated in the Appalachians in the East, the Illinois Basin in the Midwest, and the various coal basins of the Mountain region and Southwest. However, while coal, oil, and natural gas can be transported both physically and economically to other parts of the country, renewables generally cannot.

Different regions of the United States are endowed with different energy resources. However, while coal, oil, and natural gas can be transported both physically and economically to other parts of the country, renewables generally cannot.

The fact that 90% of the nation's current solar, wind, and geothermal generation resides in California is no surprise when looking at a map of where those resources are located. In fact, the potential for harnessing any of these resources outside of California and other parts of the West is limited or non-existent. While utilities in Vermont, New York, Minnesota, and Colorado may be planning wind demonstration projects, the capacity additions that they might realize will be relatively insignificant and pale beside the wind farms of California.

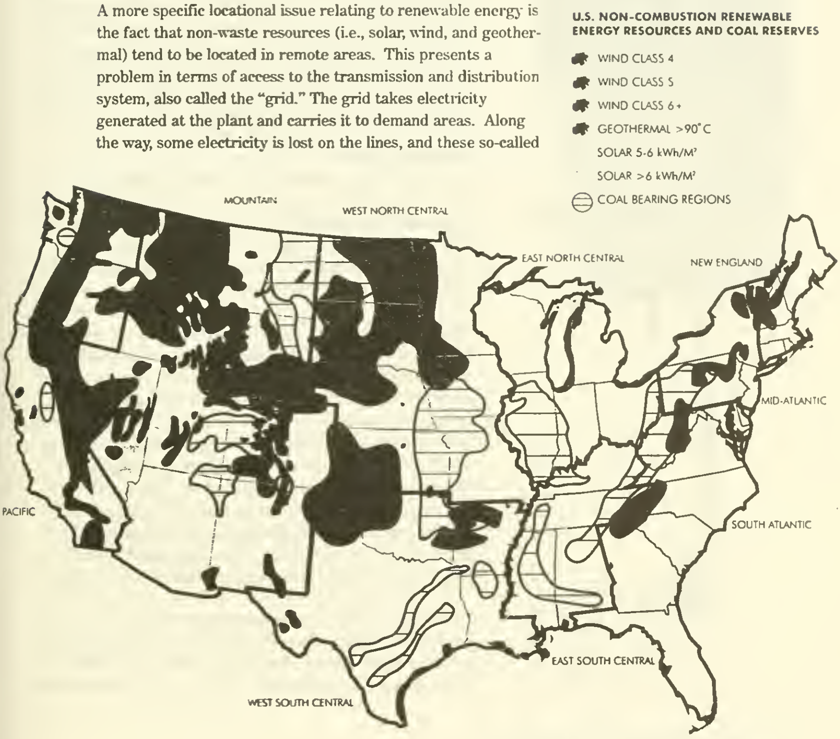
REGIONAL LEVELIZED COSTS, BASE CASE SCENARIO

¢/KWH

	SOUTH ATLANTIC	EAST NORTH CENTRAL	EAST SOUTH CENTRAL	MIDDLE ATLANTIC	MOUNTAIN	NEW ENGLAND	PACIFIC	WEST NORTH CENTRAL	WEST SOUTH CENTRAL	AVERAGE
Pulverized Bituminous Coal	3.9			4.1		4.2				4.1
Pulverized Subbituminous Coal	[illegible]	3.8	3.6		3.5		4.0	3.5	4.0	3.7
Atmospheric Fluidized-Bed Combustion–Circulating	4.6	4.5	4.3	5.0	4.2	5.1	4.7	4.2	4.7	4.6
Natural Gas Combustion Turbine/ Combined Cycle	5.0	4.3	4.4	4.3	4.0	4.5	4.1	4.0	4.0	4.3
Wind–Variable Speed Turbine–Wind Class 4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Wind–Variable Speed Turbine–Wind Class	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Wood-Fired Fluidized Bed Combustion–Residue	8.3	8.7	8.5	9.3	9.0	9.3	9.0	8.7	8.5	8.8
Wood-Fired Fluidized Bed Combustion–Energy Crop	11.5	11.8	11.7	12.5	12.2	12.5	12.2	11.8	11.7	11.8
Municipal Solid Waste–Mass Burning	8.5	9.3	9.0	10.6	10.0	10.6	10.0	9.3	9.0	9.3
Geothermal–Double Flash					9.2		9.2			9.2
Geothermal–Binary Cycle					8.0		8.0			8.0
Photovoltaic Central Station Flat Plate	28.7	31.6	32.8	42.4	19.6	38.4	24.5	24.1	23.5	27.4
Solar Thermal–Parabolic Trough					22.59		21.87		20.22	21.0

Similarly, low levels of rainfall in the West prevent agricultural and lumber industries from reaching the scale of such industries in the Southeast, Midwest, Upper Midwest, and Pacific Coast, and the low heat content of biomass fuelstocks generally prevents their economic transport beyond 50 miles. As a result, biomass generating technologies are limited in the West. The same follows for MSW and LFG generating technologies, which must be located near a metropolitan area or landfill. By comparison, coal is distributed to 47 of the 50 states for conversion into electricity.

A more specific locational issue relating to renewable energy is the fact that non-waste resources (i.e., solar, wind, and geothermal) tend to be located in remote areas. This presents a problem in terms of access to the transmission and distribution system, also called the "grid." The grid takes electricity generated at the plant and carries it to demand areas. Along the way, some electricity is lost on the lines, and these so-called



U.S. NON-COMBUSTION RENEWABLE ENERGY RESOURCES AND COAL RESERVES

RESOURCE DATA INTERNATIONAL INC • **EXECUTIVE SUMMARY 13** "line losses" increase with distance and the load on the grid. This fact, plus the considerable expense of building new transmission lines ($600,000 to $1 million per mile), severely impedes the construction of any power plant at a remote site unless it enjoys adequate economies of scale. Most renewable energy power plant projects do not exhibit such economies.

Finally, the large areas required by some renewable technologies also serve to further limit location. To supply just 10% of the nation's electricity demand with biomass generation, the U.S. would be required to plant more than 12% of all farmland with energy crops, such as hybrid poplars. For wind, one estimate calculates that 25 square miles would be required for a 50 megawatt farm. Likewise, solar thermal projects require roughly one-third square mile for each megawatt of produced electricity. Geothermal plants, however, require very little land, but are often located in wilderness areas.

ENVIRONMENTAL IMPACTS

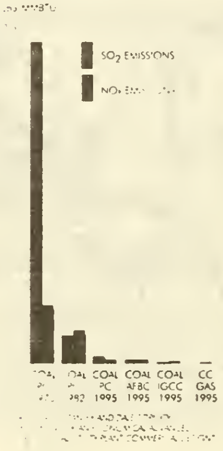
The Public Utility Regulatory Policy Act (PURPA) of 1978 is largely credited with creating the current U.S. renewable energy industry. However, PURPA originally intended to diversify the national generation mix for reasons of energy security, while renewable technologies are being pursued today because of their perceived environmental benefits.

Wind, solar, and geothermal present little, if any, emissions, and biomass, MSW, and LFG provide an alternative to landfills and open air burning of waste. Nevertheless, all energy technologies present environmental impacts. Wind, for example, consumes no fuel or water and gives off no emissions. However, it does present visual and noise pollution and kills a significant number of birds, particularly raptors, that fly into turbine blades. Solar Pv also consumes no fuel or water, but the Pv manufacturing process can involve hazardous chemicals that must be disposed of. Likewise, geothermal binary system plants create no emissions, although flash designs release hydrochloric acid and potentially hazardous hydrogen sulfides.

Combustion technologies cover a range of environmental impacts depending on the fuel combusted. The combustion of agricultural waste tends to be relatively benign, given that agricultural prunings and lumber residues would otherwise be

In 1995, state-of-the-art pulverized coal (PC) and fluidized bed combustion (AFBC) coal technologies present only 1-3% of emissions of earlier designs and compare favorably to integrated gasification and natural gas combined cycle turbines. All coal plants meet or exceed federal and state environmental regulations.

COMPARISON OF EMISSIONS FROM VINTAGE COAL & GAS TECHNOLOGIES



burned in an uncontrolled environment, and the same may be said of LFG which combusts methane gases that would otherwise have been flared or released into the atmosphere. MSW, on the other hand, generates toxic air emissions that would qualify as hazardous for other combustion technologies. Coal-fired power plants, which also employ combustion technologies, comply with a myriad of environmental regulations covering water, land, and air use. The most conspicuous of these is the Clean Air Act of 1970 and its amendments in 1977 and 1990. That legislation requires all new coal plants to employ smokestack technology that currently removes up to 95% or more of all sulfur dioxide (SO_2) emissions and provides limits on the emissions of SO_2 and nitrogen oxide (NO_X) from all existing plants. Largely as the result of these laws, SO_2 emissions in 1993 were lower than those in 1971, despite a doubling of coal-fired electricity generation over that period. When the CAAA take full effect in the year 2000, SO_2 emissions will be reduced by 62% and NO_X emissions by 33% from the levels generated by utilities in 1980.

Renewable energy advocates are increasingly heading to public policy forums as they fail to make their case in the open market. Southern California Edison calculated a cost of $560 million that would result from the state's latest round of renewable energy mandates (which were subsequently ruled out by the FERC).

PUBLIC POLICY SUPPORT

Acknowledging capability, dispatchability, economic, and location limitations, state and federal legislatures and regulatory bodies continue to support renewable energy technologies, partly as a measure of prudence in developing the energy resources of their region, but mostly because of their environmental appeal. Proponents cite the public benefits from the development of wind, solar, and geothermal resources, as well as the controlled combustion of agricultural and lumber waste in place of open burn.

However, such support comes at a cost. The California Biomass Energy Alliance, anticipating certain economic failure of its industry in an era of increasing competition, has proposed a 25¢ per month surcharge on ratepayers that the California Public Utilities Commission may consider in order to subsidize biomass plants. Southern California Edison calculated a cost of $560 million that would result from the state's latest round of renewable energy mandates (which were subsequently ruled out by the Federal Energy Regulatory Commission). In addition, EPAct provides a 1.5¢ per kilowatt tax credit to wind and certain biomass technologies, as well as a 10% investment tax credit.

States adopting externalities are also imposing a cost on the public by increasing the local cost of electricity. Under the deregulation provisions of EPAct, industrial and large commercial electricity customers will be able to shop outside the state for cheaper electricity, while residential ratepayers will not. In short, advocates for renewable energy technologies are increasingly heading to public policy forums as they fail to make their case in the open market.

> With delivered fuel prices declining by 40% to 50% in real terms from 1983 to 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas.

CONCLUSION

On the whole, renewable energy technologies have demonstrated a limited commercial ability to produce electricity, some with environmental impacts that balance positively against waste disposal alternatives. Certain technologies in certain situations can hold their own in today's competitive marketplace. In most cases, however, the lower costs of traditional generating technologies have outpaced the gains made by renewables, and some sectors of the renewables industry face contraction rather than expansion.

This study demonstrates the capabilities and limitations of renewable energy technologies and provides a measure of reasonable expectation for their continued application. All represent niche technologies that can work in specific situations, while none offer a means to replace traditional generating technologies under current market conditions. Solar and wind do not have the capability to replace baseload coal plants, and biomass does not have the capacity. Few renewable technologies are economically competitive.

Meanwhile, reductions in hydroelectric capacity, due to new reservoir management regulations, and nuclear capacity, because of plant retirements, leave coal as the primary baseload energy resource capable of meeting the nation's growing energy demand. In that regard, continued favorable economics and dramatically improving environmental controls promise to reinforce coal as the fuel of choice, especially for baseload generation, well into the twenty-first century.

Section I
Introduction And Background

Introduction

The electric power industry in the United States is undergoing major changes which are reshaping traditional roles, creating opportunities for new participants, and redefining the scope and character of government regulation. These changes are arising out of the interaction of four fundamental forces:

- Growing electricity demand resulting from economic growth;
- The economics of power generation and distribution, which work against utility companies whose costs are heavily fixed;
- Expanding utility deregulation and competition in place of traditional cost-of-service plus fixed rate of return regulation;
- Public perceptions and public policy regarding the potential environmental impacts from electricity generation.

The electric utility industry is responding to these forces by utilizing with a host of business strategies: aggressive efforts to reduce costs, corporate restructuring, "unbundling" of assets and services, flexible pricing for large customers, increased power purchases, and consolidation through mergers and acquisitions. Emerging from these efforts is a much more diversified, less tightly integrated, and above all, more competitive industry.

But the path from the traditional electric power business to a more competitive industry is strewn with issues and obstacles, some of which may resist resolution more stubbornly than is commonly assumed today. These include disagreements over the rules and procedures that should govern access to transmission facilities; the division of regulatory authority between state and federal agencies; the calculation and distribution of "stranded investments;" and various questions related to cost allocation, cost recovery and system reliability. How these issues are resolved will determine the pace and scope of change in the power industry, and in turn, will answer a question of increasing concern: *What type of generating capacity will be built to supply the nation's growing electricity needs?*

Study Objectives

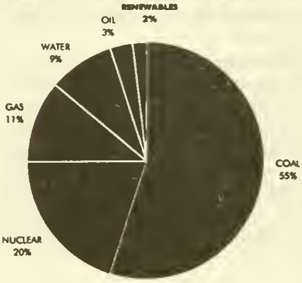
In 1994, the U.S. electric utility industry generated 3 trillion kilowatt hours of electricity from a mix of energy sources, including fossil fuels, nuclear power, hydroelectric, biomass, and emerging renewable resources such as solar and wind. For the country as a whole, the combustion of coal accounted for 55% of all utility and non-utility electricity generation, with nuclear power contributing 20%, natural gas 11%, hydro 9%, and oil 3%. Renewables (biomass, geothermal, municipal solid waste, wind, and solar) accounted for 2%.

This study explains the current U.S. generation mix, provides a comprehensive assessment of emerging generating technologies, and analyzes the economic factors that will determine which generating technologies will be competitively positioned in more open and competitive markets. The objective is to provide industry decision-makers with a perspective on the forces shaping the evolving electric power industry. The analysis and commentary are designed to identify the basic economic criteria necessary to analyze the competitive strengths and weaknesses of the emerging technologies.

The specific objectives of the study are to:

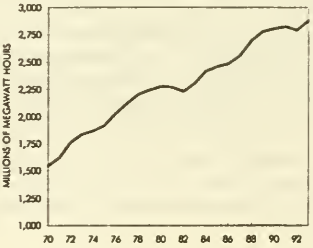
- Identify the technologies that can competitively provide new generating capacity today and into the 21st century;
- Analyze the costs and key economic factors that will determine each technology's ability to compete effectively in open and competitive power markets;
- Present a range of possible scenarios for America's future generation mix;
- Pinpoint the obstacles to widespread implementation of certain technologies or resources.

FIGURE 1-1
U.S. GENERATION MIX, 1993
(BASED ON NON-UTILITY AND UTILITY ELECTRIC GENERATION)



Source: RDI POWERdat, 1995 and EIA-AEO95

FIGURE 1-2
U.S. ELECTRICITY GENERATION, 1970-1993



Source: RDI, 1995.

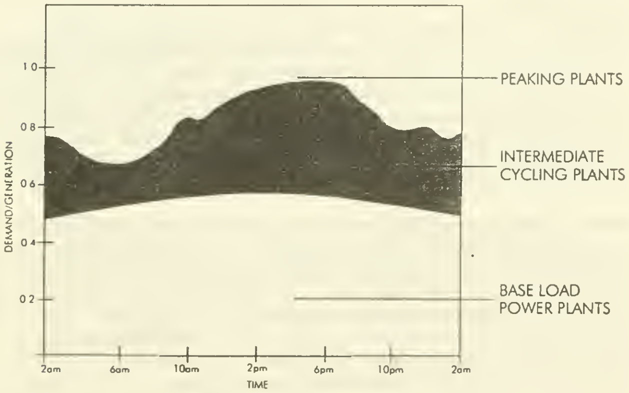
Background

HOW ELECTRIC UTILITIES WORK: A PRIMER

Most Americans would be surprised to learn that more than half of their electricity comes from the combustion of coal. In fact, coal and nuclear power serve as the primary sources for the country's baseload supply of electricity, one of three categories of electricity demand.

Baseload refers to a relatively continuous level of electricity demand and baseload unit refers to a power generator that is committed to meeting this continuous level of demand. Working in conjunction with baseload units are ***intermediate*** units, which are flexible enough to follow seasonal and daily changes in demand, and ***peaking*** units, which are employed to meet spikes in demand, such as when everyone turns on their air conditioners on hot summer afternoons. Utility companies employ generators as baseload, intermediate, or peaking depending upon their costs, with the least expensive units running first to cover baseload demand and the most expensive running last to cover peaking demand. This ranking of generating units by cost is called the ***dispatch order*** and is the central concept behind the economics of electricity supply.

FIGURE 1-3
TYPICAL UTILITY DISPATCH PROFILE



Source RDI, 1995

Generator costs consist of two basic components, fixed and variable. ***Fixed costs*** consist of capital expenditures such as construction outlays, and ***variable costs*** include such items as fuel, labor, and consumables. Nuclear power plants have extremely high fixed costs, but very low variable costs due to their low level of fuel consumption. Likewise, hydroelectric dam construction requires large capital expenditures, while the cost of water, which spins the electricity-generating turbines, is practically free. As a result, nuclear power plants and hydro plants almost always lead off the dispatch order, followed by coal, which has mid to high capital costs and low fuel costs. Natural gas and oil units enjoy lower fixed costs because they tend to be smaller, modular units, but fuel prices above the price for coal place them higher in the dispatch order, usually in peaking positions. Intermediate units can either be underutilized coal plants or highly utilized gas and oil plants.

In addition to variable costs, the capability and availability of the various fuels and technologies dictates their dispatch positioning. ***Capability*** refers to the utility's ability to dispatch a unit based on its technological characteristics, and ***availability*** refers to maintenance issues. Nuclear and coal plants are usually run at 100% of availability because they cannot easily be operated at varying levels to match peaking demand, requiring hours to effect a change. Conversely, natural gas and oil units are well-suited to peaking since they can generally ramp up generation within minutes, like stepping on the gas pedal of a car. Hydro can be run as baseload when water is plentiful, generally in the Spring, or as peaking when water is lacking. Other emerging renewable technologies can be difficult to dispatch due to the unpredictability of the natural forces, such as sun and wind, on which they rely.

A generating unit's performance can be ascertained by reviewing its annual ***capacity factor***, which is the annual generation of a unit divided by its total capacity to generate. Baseload units may have capacity factors anywhere from 50% to 100%, while intermediate units are in the 30% to 40% range and peaking units at around 10% to 20%, or less. Generation is commonly measured in kilowatt hours and capacity in megawatts. To determine a capacity factor, generation must be divided by the number of hours in a year (365 days x 24 hours = 8,760 hours per year) or capacity multiplied by that same factor. Therefore, a 1,000 megawatt unit with 500 million kilowatt hours of generation in a year would have a capacity factor for that year of 57%, which is the result of (500 million/8,760 hours)/1,000.

In addition to being electricity generators, utility companies are also electricity distributors with billions of dollars invested in ***transmission*** and ***distribution*** lines, often referred to as the ***grid***. The grid can fairly be compared to a water system since, like water, electricity flows along the path of least resistance. A plant generating power connects with the grid at the ***busbar***, usually just inside the plant property, where electricity is "stepped-up" to transmission voltage of at least 230 kilovolts. The electricity flows across the grid in the direction of demand and is "stepped-down" by transformers to a voltage below 230 kilovolts for carriage on distribution lines, which eventually deliver the electricity to factories, offices, and homes.

A key characteristic of the grid is that it must always carry more electricity than required by demand. This margin is necessary to ensure that supply will never be lower than demand and to cover line losses. ***Line loss*** occurs as the result of temperature changes, sags in the line, heavy electricity loads, and distance the electricity is carried, among other factors. Line losses are usually below 5%. Cooler temperatures, higher-grade line materials, and shorter distances all help lessen line loss. Therefore, it makes sense to generate electicity as close as possible to demand centers.

Because of the high capital cost of the grid, utilities try to keep as much electricity on their lines as possible and conduct extensive cost analyses before building line extensions. In recent years, this fact has given rise to the concept of the ***distributed utility***, which entails placement of small generators at new load (i.e., demand) centers as a cost saving alternative to installing new high voltage lines.

High capital costs for new generation and transmission capacity have also led to utility interest in ***energy conservation*** measures, or demand side management (DSM). By implementing DSM, utilities attempt to slow growth in electricity demand and forestall the need for new investments. Conservation and load management measures cover a wide range of technologies and controls, as well as financial incentives for customers to reduce their energy usage or shift it to off-peak periods.

Working closely with state ***public utility commissions*** (PUCs), electric utilities strive to keep their customers' electric bills as low as possible and to earn a profit for their shareholders by utilizing their generating and distribution assets in the most economical way possible.

THE CHANGING REGULATORY ENVIRONMENT AND MARKETPLACE

Until recently, electric utilities (particularly investor owned utilities) operated as natural monopolies within their individual service territories, albeit with PUC oversight. Success has been measured primarily by shareholder returns and the ability of the utility to draw industry into their territories. In recent years, however, three key pieces of federal legislation have fundamentally altered the industry by significantly increasing the importance of environmental economics and the intensity of competition.

CLEAN AIR ACT AMENDMENTS OF 1990 Signed into law in November 1990, the Clean Air Act Amendments of 1990 (CAAA), specifically Title IV, provides for annual U.S. sulfur dioxide (SO_2) emissions to be reduced by 10 million tons and annual nitrogen oxide (NO_x) emissions to be reduced by 2 million tons. Both SO_2 and NO_x are identified in the CAAA as contributors to acid rain. These reductions, a 56% cut from 1980 utility SO_2 emission levels and a 33% cut from 1980 utility NO_x levels, will be achieved in two phases, with Phase I starting January 1, 1995, and Phase II starting January 1, 2000. To meet the reduction goals, the Environmental Protection Agency (EPA) will assign individual emission limits to each electric utility.

A unique aspect of the CAAA is that it allows the market to determine the manner in which it will comply with the emission limits. Utilities may retrofit smokestack ***scrubbers*** and/or ***switch*** from higher sulfur fuels to lower sulfur fuels, among other options. They may also choose to overcomply with the limit or undercomply. Those under-complying may cover their excess emissions by purchasing surplus emission permits, called ***allowances***, from those utilities overcomplying. Because allowances have a monetary value and can be bought and sold in an open market, their cost (and thus the cost of emissions) has been incorporated into the cost of electricity production.

This integration of the emission costs has spawned the concept of ***environmental dispatch***, whereby utilities increase generation at their cleanest units and decrease generation at less clean units. In other words, the CAAA has altered the existing dispatch order by making cleaner power plants relatively more economical. A more detailed discussion of the CAAA is provided in Section III of this study.

While the CAAA are shifting the economics of electricity generation, the Energy Policy Act of 1992 (EPAct) is standing electricity economics on its head. A far reaching piece of legislation, EPAct is designed to improve the efficiency of U.S. energy markets by introducing more competition. The law continues the work of the Public Utility Regulatory Policy Act of 1978 (PURPA), which introduced the first semblance of competition into the industry.

PUBLIC UTILITY REGULATORY POLICY ACT OF 1978 Passed during the last energy crisis of the 1970s, the Public Utility Regulatory Policy Act of 1978 (PURPA) was designed to diversify the nation's energy base and to take advantage of energy sources that were otherwise being under-utilized. To that end, utilities were required under the law to purchase power from non-utility generators (***NUGs***) that met qualifying facility (***QF***) requirements and utilities were required to pay for power at the utility's avoided cost (i.e., the theoretical cost at which the utility could build its own new capacity). PURPA provided QF status to boilers cogenerating steam for both industrial purposes and electricity production, as well as to small power producers utilizing renewable sources of energy and meeting certain size requirements.

Throughout the 1980s, NUG developers as a whole, and renewable energy developers in particular, gained experience and improved their technologies at such sites as the Altamont Pass wind farm in California. By the late 1980s and early 1990s, many electric utilities were struggling with heavy fixed costs and began to rely on NUGs to build their incremental capacity requirements rather than build their own power plants. However, in recent years most states have moved away from the high, theoretical avoided cost approach to a ***bidding*** system that favors low-cost producers.

ENERGY POLICY ACT OF 1992 The Energy Policy Act of 1992 (EPAct) has intensified that situation in two ways. First, the act created a new category of NUG called electric wholesale generator (EWG). Prior to EPAct, NUG projects not meeting QF status were subject to Securities and Exchange Commission (SEC) oversight just like a regular utility under the Public Utility Holding Companies Act and were generally avoided by the private developers. EPAct, therefore, created an environment allowing the development of stand-alone private power plants with generating capacities independent of QF requirements. Secondly, EPAct opened up competition between utilities. While still an evolving situation, utilities have the ability under EPAct to sell power to industrial, municipal, and other utility customers across their competitors' transmission lines. This unprecedented level of competition is leaving utilities with high fixed costs and stranded investments in an even more vulnerable position and more reliant on sources of outside capital. NUG developers are one such source.

PUBLIC POLICY AND RENEWABLE ENERGY

All three pieces of legislation discussed above present broad and even profound challenges that go to the core of the nation's electric utility industry. While repercussions in the larger picture land on the ability of companies to adapt and even survive, somewhat less prominent pieces of the legislation touch on the nature of electricity generation itself and energy choices.

In 1978, the passage of PURPA almost single-handedly created the renewable energy industry. Utilities anxious for energy diversification and investors quick to take advantage of federal and state tax incentives rapidly built thousands of megawatts of renewable energy generators through the 1980s. This new industry received further encouragement with the CAAA in 1990, given that the incorporation of emissions into the cost of electricity production promised to improve the competitiveness of new technologies such as wind, solar, and geothermal.

EPAct took an even stronger stand for renewable energy in 1992. In addition to encouraging advanced nuclear power plant development and environmentally sound uses of coal and natural gas, EPAct also provides a 1.5¢ per kilowatt hour tax credit for electricity generated from wind or certain types of biomass, a permanent 10% investment tax credit for solar and geothermal development, and authorization for the U.S. Department of Energy to assist in the commercialization and development of renewable energy sources.

Yet, despite this federal legislative support, in addition to the interest and support of state legislatures and PUCs, renewable energy is having a difficult time competing with traditional technologies and energy resources in the 1990s. The following sections examine each renewable technology in terms of its technical characteristics, environmental aspects, economics, and overall ability to play a part in the future generation mix.

Section II
Renewables

Introduction and Background

Passage of PURPA in 1978, in conjunction with the energy crises of the 1970s, spawned the commercial development of a wide variety of alternative energy technologies in the United States. Despite the fact that the resources behind these technologies are referred to as "renewable," there is little commonality between their respective physical characteristics. Some resources, such as wind, are truly renewable, while others, such as geothermal, are degraded during energy conversion processes. Other demarcations occur between combustion and non-combustion technologies, and those that are intermittent and dispatchable, land intensive and non-intensive usage, and modular and non-modular.

RENEWABLE ENERGY TECHNOLOGIES

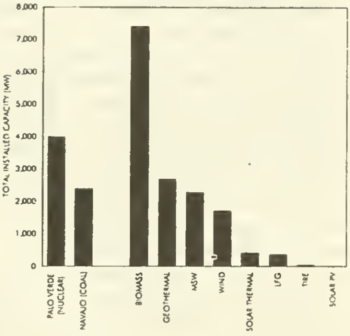
NON-COMBUSTION	COMBUSTION
Wind Turbines	Biomass
Solar Phatavoltaic	Municipal Solid Waste ("MSW")
Solar Thermal	Landfill Gas ("LFG")
Geothermal	
Other (Ocean and Hydrogen)	

Hydroelectric is not considered a renewable in this study because it is a proven technology and no large, undeveloped sites exist in the United States.

In 1993, the total installed electric generating capacity of all alternative, renewable sourc-es of energy represented 2% of total U.S. generating capacity and generation (including utility and non-utility).[1] Assuming an admittedly unrealistic best case scenario for further development of these technologies by the years 2000, 2005, and 2010, the combined total for all renewable resources could represent 4%, 8%, and 11%, respectively, of all U.S. electricity generation (see Section IV of this study). Although renewables have a role to play, they clearly cannot replace traditional sources of energy in the U.S. electricity generation mix by 2010.

It is evident that high prices for traditional energy resources during the early to mid-1980s created an environment in which alternative energy technologies could take root and compete. In real terms, oil prices paid by utilities rose more than 346%, and natural gas 352%, from 1972 to 1981. By 1993, however, oil had fallen by 72% and natural gas by 42% from 1981 levels. Likewise, coal prices slid by 43% between 1981 and 1993. On the whole, oil prices in 1993 were 28% over 1972 and natural gas prices were 164% over 1972.[2] These price trends for traditional energy sources correlate closely to a rise and fall in renewable energy capacity additions. If not for long-term power sales agreements, such as California's ISO4 agreements, many sectors of the renewable energy industry may even have lost capacity by the early 1990s.

FIGURE 2-1
U.S. INSTALLED RENEWABLE ENERGY CAPACITY, 1994
VS. CAPACITY OF ONE NUCLEAR AND ONE COAL-FIRED PLANT

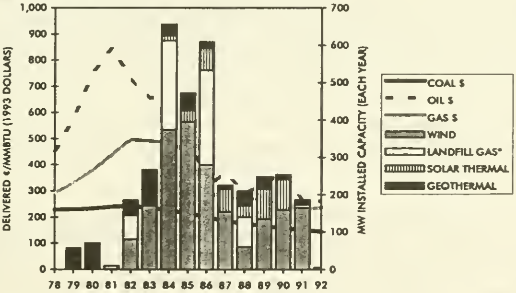


Source RDI, 1995.

The Role of California

Relying heavily on oil-fired electricity generation, California was hit especially hard during the energy crises of the 1970s. That fact, plus tremendous economic growth, caused the state to encourage energy development across a wide spectrum. California electric utilities joined consortia in building coal-fired plants, such as the 2,400 megawatt Navajo Generating Station in Arizona and the 1,586 megawatt Mohave station in Nevada, and nuclear plants, such as the 4,000 megawatt Palo Verde facility in Arizona. In addition, the California Public Utility Commission (CPUC) became aggressive in promoting sources of non-utility generation under PURPA.

FIGURE 2-2
RENEWABLE CAPACITY ADDITIONS VS. DELIVERED FUEL PRICES, 1978-1992
ADJUSTED FOR INFLATION (1993=100)

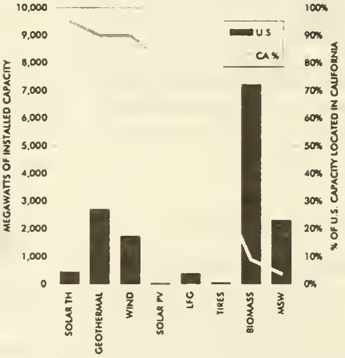


*LFG Based on number of projects per year and mean capacity of 4 mw.
Data not available for Biomass and Municipal Solid Waste.
Solar Pv additions of 14 MW not shown due to small size.

Source: RDI POWERdat Database (1995), AWEA (1994), GAA (1992), Geothermal Society (1992), SAND91-7014.

Because PURPA contained a clause providing QF status to projects based on renewable energy and because the state is rich in such renewables, California utilities quickly came to hold non-utility generation purchase agreements for electricity generated from geothermal, wind, solar, biomass, municipal solid waste, scrap tire, and landfill gas projects. By the 1990s, 36% of the nation's renewable energy capacity was located in California, with over 90% of all solar, wind, and geothermal generating capacity located in the state. This fact is important given the increasing number of renewable energy project failures within the California industry.

FIGURE 2-3
CALIFORNIA'S PERCENTAGE OF TOTAL U.S. RENEWABLE CAPACITY, 1994



Source: RDI, 1995

In 1991, the California biomass energy industry reached an all-time high of 850 megawatts of generating capacity. By 1995, however, that number had dropped to 635 megawatts and is projected to fall to 100 megawatts by the year 2000.[3] This dramatic failure in the biomass industry is also reflected in California's solar and geothermal industries, among others, and results from an inability to compete with traditional energy sources in today's power market. That California's renewable energy industry has survived to date is largely the result of the ISO4.

Interim Standard Offer No. 4 (ISO4) is a standard power sales agreement signed by independent power projects in California between 1982 and 1988. The CPUC actually mandated a series of standard power sales agreements during the 1980s, including ISO2 and ISO4. ISO4 stands out because it provides a thirty-year term with a fixed energy price during the first ten years, escalating according to an energy price forecast, and a floating energy price from year eleven to year thirty. With oil prices in 1995 of about $18 per barrel versus a typical ISO4 forecast of $95 per barrel, market prices for power stand at 2¢-3¢ per kilowatt hour versus ISO4 contract prices which have escalated to around 12¢ per kilowatt hour.[4]

As a result, as ISO4 agreements reach their "11th Year" and "subsidized" contract prices drop to market, most facilities holding these agreements are becoming uneconomical and are failing. Renewable energy groups are currently lobbying the state for support. The California Biomass Energy Alliance, for example, has submitted a proposal to the CPUC and the California legislature that would institute a ratepayer surcharge of $0.25 per month for five years to further subsidize the state's biomass projects.[5] At the same time, however, the Federal Energy Regulatory Commission recently threw out the CPUC's aggressive PURPA program which set forth requirements for utilities to purchase non-utility generated electricity at costs above market. This ruling further pushes the issue of support for renewables into the public policy arena (i.e., legislatures and elected officials) and away from the regulatory arena (i.e., PUCs, appointed officials, and staff).[6]

Without public policy intervention, major setbacks will occur in California's biomass, solar, and geothermal sectors (and wind to a lesser degree) as ISO4 contracts expire through the remainder of the 1990s. Assuming no further capacity additions, total national renewable energy capacity could shrink by 10% to 25% by 2000. Meanwhile, development of new projects will continue to be difficult, if not impossible, for most renewables without similar public intervention, such as subsidization by ratepayers and taxpayers.

Moving Forward

As the other states consider their energy future, PUCs and legislators are examining the costs and benefits of all available energy technologies. This examination is focused not only on economics, but also on the environmental aspects of each technology. Although many officials may start with the concept that energy resources are basically interchangeable, save for environmental characteristics, nothing could be less true. Critical differences are evident in terms of resource location, capability, availability, and cost, in addition to environmental impacts.

To begin, renewable resources generally cannot be transported. Therefore, solar panels can be utilized only where solar radiation is abundant, wind turbines where wind is abundant, and geothermal where hydrothermal resources are present. All three of these resources are concentrated primarily in the western half of the U.S. Renewable combustion technologies are more widespread with biomass more apparent in the eastern half of the U.S. and Pacific coast, and Municipal Solid Waste (MSW) available near large population centers, such as Los Angeles and New York. As a result, Wyoming cannot readily generate electricity from trees and Pennsylvania cannot readily generate from wind.

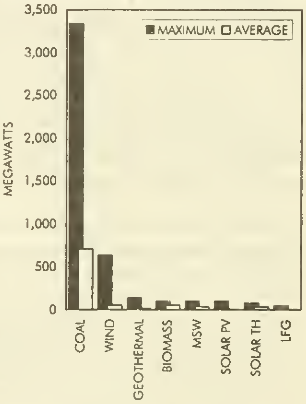
After assessing its renewable resource potential, each state must consider the capability of the various resources to meet its electricity needs. Some renewable combustion and geothermal technologies can serve in a baseload or intermediate dispatch position in spite of their higher costs. That is, utilities can control the amount of electricity generated by these technologies to meet demand as needed if they are willing to pay the higher generating costs. Conversely, intermittent renewable technologies, such as wind and solar, cannot be controlled. To fit generation from these technologies into the dispatch order, utilities must predict wind and solar patterns based on years of observed data (usually with a reasonable degree of accuracy) and either back-off intermediate unit generation during strong winds and periods of solar radiation or ramp-up peaking units during wind lulls and cloudy days. In either case, the grid is accommodating the resource rather than vice versa.

Another factor in assessing a technology's capability is unit capacity. MSW units may work in a baseload position, but the relatively small size of individual MSW plants may not significantly add to overall supply. Renewable generators come in a variety of sizes, from a 0.07 megawatt landfill gas (LFG) unit to a 100 megawatt whole tree biomass boiler. Modular technologies use collections of small units to create larger plants. Wind, for example, can utilize hundreds or thousands of turbines at 0.5 megawatts or lower to create a 100 megawatt wind farm. Modularity may lower up-front capital costs by allowing the first units in place to earn money while additional units are being installed. It may also increase costs, as in the case of MSW units, by removing the economies of scale from expensive environmental control systems.

Typical of most new technologies, renewable energy has made important advances in lowering costs during the early years of development, with additional gains becoming more difficult as costs go lower. In addition to improved technology and efficiencies, renewables have also been aided by IRS rules allowing accelerated depreciation and by EPAct's provisions for a 10% investment tax credit and a 1.5¢ per kilowatt hour subsidy (for wind and certain biomass technologies). As a result, wind fell from 40¢ per kilowatt hour in the early 1980s to 7¢ per kilowatt hour by the early 1990s. Likewise, solar Pv improved from many dollars per kilowatt hour to 20¢ to 30¢ per kilowatt hour, and geothermal from greater than 15¢ per kilowatt hour to about 8¢ per kilowatt hour.

The greatest support for renewables today stems from the public perception that such energy sources are environmentally benign. To be sure, wind and solar technologies do not generate emissions, MSW combustors serve as an alternative to landfills, and some biomass plants serve as an alternative to open agricultural burns. Nevertheless, all energy technologies present environmental impacts. Wind can cause visual and noise pollution and is also the subject of studies on avian mortality and adverse impacts on micro ecosystems. Geothermal flash systems emit hydrochloric acid and concentrations of sulfur. MSW emits toxins and furans, and solar panel manufacturing involves the processing of hazardous chemicals. These impacts must be weighed and balanced against energy alternatives, as well as waste disposal alternatives in the case of MSW, LFG, and certain biomass.

FIGURE 2-5
AVERAGE AND MAXIMUM PLANT CAPACITIES



Source RDI, 1995.

Land use is another factor influencing the appropriateness of renewables. To generate just 10% of the nation's electricity, biomass plants burning a dedicated energy crop (i.e., trees) would require 41 million acres of land, equal to 12% of all U.S. farmland or 134 cities the size of Los Angeles.[7] Wind turbines must be spaced to avoid energy loss from wake effects, such that a 50 megawatt wind farm might require up to 25 square miles. On the other hand, geothermal plants require very little land, but their resource is often located in national parks or wilderness areas.

Finally, renewable energy technologies are frequently appropriate in remote (i.e., non-grid connected) situations. In that regard, a residential windmill or solar panel acts very much like an energy conservation application, also called demand side management (DSM). Remote renewable technologies and DSM are incorporated into the electricity demand growth rate assumptions in the generation forecast in Section IV.

Energy Resource Attributes

Renewables can be compared between both themselves and traditional energy sources by assessing the following ten attributes as defined by the National Renewable Energy Laboratory:[8]

CAPABILITY

The limits on the ability of a unit to supply power in a given period under normal conditions. Such limits include the size, or capacity, of the unit and constraints arising from the unavailability of fuel or prime mover (such as wind or sun). This study considers the intermittence of sun and wind to be factors in determining capability, although some sources consider intermittence to be an availability issue.

AVAILABILITY

Any reduction in the capability of a unit to generate electricity under normal conditions. Routine maintenance, unplanned maintenance (i.e., breakdowns), refueling, and modifications are prime causes of unavailability and thus factors in determining availability.

DISPATCHABILITY

The degree of control that a utility has over the hour-by-hour and minute-by-minute generation from a unit. This study frequently incorporates the concept of dispatchability into the concept of capability to describe the dispatch applications of certain technologies, since the former is a refined definition of the latter.

MODULARITY

The characteristic of a generation site consisting of a number of small units, or modules. Modularity has implications for installation, increased capacity, availability, and capital investment risk.

LOCATION

This study considers location to refer to geographic areas compatible with the various technologies, resource availability, and specific siting issues. The cost of connecting remotely located generating stations to the grid is a major consideration in many instances, with line construction ranging from $600,000 to $1 million per mile.[9]

COST

Costs can be defined either tightly as the pure cost of generation or loosely as all potential costs incurred or avoided as the result of employing a technology. Since a quantitative analysis of all potential costs incurred or avoided usually incorporates speculation and controversial assumptions, this study quantifies only the pure cost of generation, qualified by an identification of the potential costs.

EFFICIENCY

The heat rate, the standard measure of efficiency, is an important parameter in the economics of most resources where fuel is a major component of the total cost of power. A boiler heat rate of 10,000 Btu per kilowatt hour is more efficient than a boiler heat rate of 14,000 Btu per kilowatt hour because less heat is required to create one kilowatt hour. This should not be confused with the heat content of fuels. Solar and wind technologies do not have heat rate efficiencies since they do not combust fuel.

INCENTIVES

The subsidies provided by the government to promote the development of a technology. EPAct provides a 1.5¢ per kilowatt hour tax credit to wind and biomass projects (burning a rotating crop intended for energy use) entering commercial operation prior to July 1, 1999 and a nonterminating 10% investment tax credit to solar and geothermal projects. Even more importantly, tax laws allow renewables to accelerate depreciation more quickly than allowed for traditional energy technologies.

EXTERNAL COSTS AND BENEFITS

The cost or benefit theoretically borne by others as aconsequence of operating a technology for which the others receive no compensation or make no payment. These externalities may include environmental and regional economic impacts. Because of the speculative and controversial nature of externalities, this study does not discuss them in relation to any specific technology.

RISK DIVERSITY

Risk describes any unanticipated, unfavorable condition, including unanticipated availability problems with a technology, unfavorable changes in market conditions, and unexpected changes in legislation. Developers of power projects usually quantify their areas of risk, and factor that into their economic projections. Any new technology or energy source that can demonstrate its economic value must be considered a benefit by way of adding to the nation's energy diversity and acting as a hedge against risk. Further, utilities should consider investigation into all potential energy resources, including renewables, as prudent relative to maximizing their company's resources. This study assumes that all renewables share diversification benefits, with individual technology risks described under costs and external impacts.

Using these attributes, an assessment of each renewable energy source follows.

Wind Power

Introduction

The United States is the largest producer of wind generated electricity in the world with installed capacity totaling 1,725 megawatts as of 1995.[1] By way of comparison, the Palo Verde nuclear power plant and the Navajo coal-fired power plant, both of which serve California and the southwest, are rated at 4,000 megawatts and 2,400 megawatts, respectively. Although more than 90% of total U.S. wind capacity is located in California, utilities in six other states currently operate pilot projects.

Capability

Beyond capacity ratings, direct comparisons are difficult to make between baseload generating units and wind. For example, where the Palo Verde nuclear plant operates at an annual capacity factor rating of 80% to 95%, depending on its refueling cycle, and Navajo operates at a level of 75% to 80%, wind turbines operate at a typical 29% capacity factor for newer units.[2] Indeed, one of the most fundamental characteristics of wind power is intermittence of power; that is, wind cannot be controlled or entirely predicted.

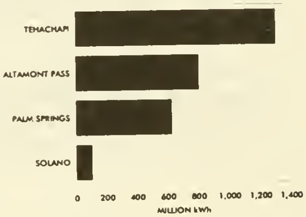
To meet the challenge of intermittence, utilities and wind developers rely on detailed studies of wind patterns and on backup generation employing traditional peaking technologies. For example, Northern States Power has compiled seasonal and even daily data on wind patterns at its Buffalo Ridge, Minnesota, pilot wind project. These data clearly show a seasonal pattern, much like hydro, as well as daily patterns.[3] Prior to installing wind projects, the developer or utility must consider how these seasonal patterns and daily profiles fit into the

TABLE 2-1
ESTIMATED GRID-CONNECTED WIND ENERGY CAPACITY BY COUNTRY, 1994

COUNTRY	MW INSTALLED
UNITED STATES	1,725
DENMARK	520
GERMANY	330
UNITED KINGDOM	145
NETHERLANDS	132
SPAIN	55
GREECE	35
ITALY	10
OTHER OECD	70
INDIA	50
CHINA	25
REST OF WORLD	75

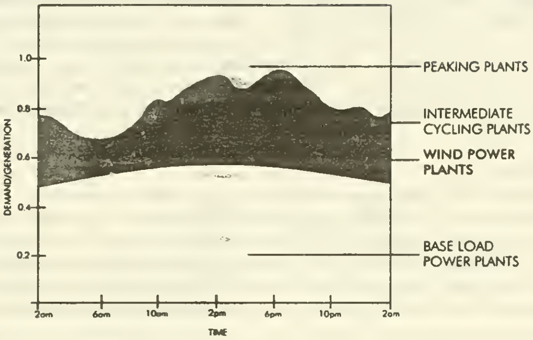
Source Energy Resource Center, The Netherlands, 1994/AWEA

FIGURE 2-6
CALIFORNIA WIND GENERATION, 1993



Souce: Paul Gipe and Associates, 1994 (Compiled from utility data).

FIGURE 2-7
WIND'S POSITION IN A TYPICAL DAILY DISPATCH PROFILE



Source: For Utility Wind Interest Group, by NREL Technical Information Program, July, 1992

utility's load profile. If wind is present during mid-day in hot summer months, then a fit may exist. However, if wind results primarily from cooling of the earth at night when demand is low, then a fit may not exist.

Even with a clear understanding of how wind patterns fit a load profile, wind remains unpredictable and may blow and abate several times in any given hour, if at all. As a result, natural gas and oil peaking units have been identified as complementary technologies capable of providing quick backup generation to fill the valleys in wind generation.[4] In other words, a utility might find it necesssary to build *both* a wind and a natural gas unit in order to provide reliable power. In this configuration, wind power actually serves as a hybrid technology.

Finally, the largest wind farm in the United States is at Tehachapi in California. Based on information provided by the American Wind Energy Association, the installed capacity of this facility is 638 megawatts, or one-quarter the size of the Navajo coal plant. Tehachapi's generation, however, contributes well less than 1% of all electricity consumed in California, while Navajo's generation equals 7% (although only a portion of Navajo's power is actually sold into California). It is difficult to determine the land area occupied by Tehachapi because the site is actually a collection of farms. However, Altamont Pass (the largest wind site in terms of area, but second to Tehachapi in capacity) occupies 80 square miles versus the 1.5 square miles occupied by Navajo.[5]

Again, using capacity as an indication of capability, it is difficult to make comparisons between wind power and traditional baseload technologies.

AVAILABILITY

Complicating capability is the availability of wind technologies. Early versions built in the 1980s have experienced availability as low as 40% to 60% due to maintenance problems, and it is not uncommon to see motionless turbines on windy days at the Altamont Pass and Palm Springs wind farms in California. Manufacturers of more recent versions, however, are claiming availability ratings will be in the high 90% range. Advances in design have centered on state-of-the-art blade architecture (wind foil) and more efficient and reliable turbines.[6]

MODULARITY

Modularity has been offered as a positive factor in the reliability of wind farms. Given 17,000 turbines in California (averaging about 100 kilowatts, or 0.1 megawatt, in size), a breakdown in one turbine should not significantly impact the availability of the farm as a whole. Although this stands to reason, experience has shown that conditions causing the breakdown of one turbine usually have the same effect on many others. Therefore, modularity may improve reliability and availability in some instances while not in others.[7]

Modularity has also been offered as a benefit of wind turbines because of the relative ease and short lead time involved in adding new capacity. Again, this stands to reason and makes great sense from the standpoint of expanding the capacity of a wind farm. From the larger perspective, however, the addition of even 100 new turbines each with a capacity of 0.5 megawatts, the upper limit of optimum turbine size, would create only 50 megawatts of new capacity operating at a 30% capacity factor. For a utility the size of Pacific Gas & Electric, which purchases power from Altamont Pass, this is a minimal increase at best.

Given realistic expectations of the magnitude of capacity additions, modularity also serves as a benefit by hedging capital investment risk. Individual units can begin generating revenue upon installation, as compared to large scale traditional technology plants which may require one to five years before entering commercial operation. Further, investment in modular technologies can be strung out over several years, whereas traditional technology requires a single, large capital commitment. On the other hand, modularity cannot garner the economies of scale possible with traditional technology.

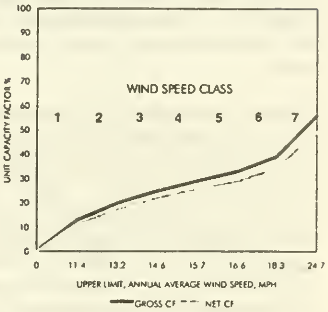
LOCATION

The actual installation of a turbine is the least complicated aspect of developing wind power. Wind resources must first be identified. Minnesota Power, studying the potential for wind power in their territory in a June 1994 report, cited EPRI's Technical Assessment Guide (TAG) in recognizing Class 5 wind speeds with an annual average wind speed of 15.7 to 16.6 miles per hour as the regime at which wind turbines can become economical. At that level, units can achieve a 30% capacity factor. The National Wind Technology Center, on the other hand, claims that Class 4 wind speeds with as little as 13 miles per hour can now produce electricity economically.

Assuming the lower speeds of Class 4, data indicate that wind resources are limited regionally, concentrated mainly in the West, upper Midwest, and pockets of the Northeast. In fact, over 90% of all U.S. wind resources are located in Great Plains states.[8] As would be expected, the existing and planned wind projects identified by the Utility Wind Interest Group correlate strongly to the location of wind resources at Class 4 and above.

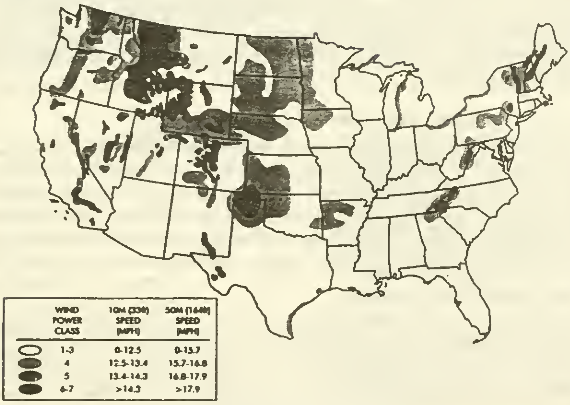
Once wind resources have been identified, a site must be selected that can provide anywhere from 24 acres to 160 acres per megawatt. In its analysis, Minnesota Power found that a 50 megawatt wind farm would require anywhere from two square miles (using the densest estimate available) to 25 square miles.[9] These substantial wind farm land requirements, which typically

FIGURE 2-8
WIND UTILIZATION RATES TO WIND SPEED
(FOR A 30 METER HUB-HEIGHT TURBINE)



Source Reference 1, EPRI Technical Assessment Guide (TAG) 1993, p 8-105

FIGURE 2-9
U.S. WIND RESOURCES



Source: NREL "Profiles in Renewable Energy: Case Studies of Successful Utility-Sector Projects." Golden, CO., 1994 see less than 5% of the land actually occupied by turbines, are necessary in order to avoid wake effects between rotors. Stan Frandsen of Riso National Laboratory presented data in a paper at the Wind Power 1994 Conference indicating that spacings of 20 rotor diameters are required in order to avoid significant losses in performance (less than 2.5%) due to wake effects. Actual land requirements will be site specific and based on rotor size, hub height, wind regime, and terrain.

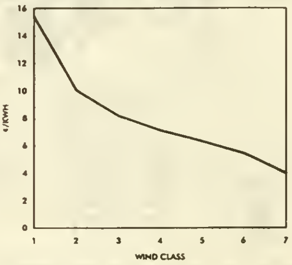
An equally important siting consideration is transmission access. Given the high cost of building and maintaining transmission lines, the site of any new small to intermediate sized generating unit, regardless of technology, must be located close-to grid access. The sheer scale of projects the size of the Palo Verde nuclear plant can economically justify new lines, while 50 megawatt wind farms might not. Assuming that the grid is accessible, transmission lines must provide enough capacity to handle the new generation. A drawback specific to wind and other intermittent energy sources is that generation may range from zero to 100% of the unit's rated capacity during the year. Therefore, space must be maintained on the line to handle up to 100% of the unit's rated capacity even though the annual average will run only about 30%, leaving 70% of the allotted line capacity un-utilized. Obviously, the larger the unit or farm's rated capacity, the greater the utility's concern.

COSTS AND INCENTIVES

While transmission is a very real component of wind generating costs, it can be calculated only on a project-specific basis. Therefore, this study compares the levelized generation costs of the various renewable technologies without attempting to identify transmission, land cost, or other site-specific costs. On that basis, various sources identify state-of-the art wind generation production costs at anywhere from 3.9¢ per kilowatt hour, according to the American Wind Energy Association, to a range of 7¢ to 9¢ per kilowatt hour as estimated by Minnesota Power, including current subsidies.

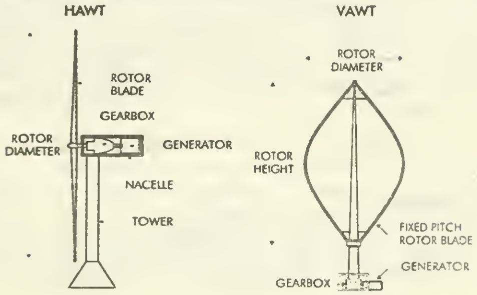
RDI calculated levelized production costs for wind at between 4.2¢ to 8.7¢ per kilowatt hour in a wind regime of Class 4. These numbers are based on NREL's Concept 1 design, a 0.2 megawatt variable speed turbine with control electronics and advanced design airfoils mounted on a 50 meter tower. Accelerated depreciation and a 1.5¢ per kilowatt hour federal subsidy have been included. Without the subsidy, costs would be 5.7¢ to 10.2¢ per kilowatt hour. Variances result primarily from alternate discounting assumptions, although a full explanation is available in Section IV and the Technical Appendix.

FIGURE 2-10
LEVELIZED PRODUCTION COST
OF WIND POWER, BY WIND CLASS



Source: See Section IV of this Study

FIGURE 2-11
HORIZONTAL AXIS (HAWT) AND VERTICAL AXIS (VAWT) WIND TURBINES



Source: BA

Again, actual costs will be project specific and will depend on land cost, wind regime, technology, and location. Cost improvements of 0.5¢ per kilowatt hour have been gained by employing turbines designed for Class 4 wind regimes in Class 5 winds. Other economic considerations include hub height. Ten and fifty meter hub heights are general standards. The advantage of the 50 meter hub height is that winds often have speeds with 20% to 30% more energy 60% further from the ground.[10] However, this is not always the case and the increased height significantly increases the project's cost. As such, height decisions must be based on the available wind resource, the technology employed, and an economic evaluation of costs and revenues. Also, costs will vary between regions, with northern sites requiring more costly blade materials to contend with icing and dirt build-up.

Overall, wind technology has made impressive gains since 1980 when costs were 40¢ per kilowatt hour and higher. Typical production costs of units installed during the 1980s are between 6¢ and 9¢ per kilowatt hour and their power contracts pay between 10¢ and 16¢ per kilowatt hour. Recent bids for wind power have been reported as low as 5¢ per kilowatt hour although exact terms of the bid are not available.[11] As with any maturing technology, major gains were made in the early years with improvements in costs slowing with maturity.

The most significant advances have included optimization of scale, settling on an intermediate turbine size of 0.2 to 0.5 megawatts to combine the economies of 1 megawatt units with the availability of 0.04 kilowatt units, and computerization of operations to lessen down-time by immediately alerting maintenance crews of an outage. Operating costs have also been reduced by the general accumulation of experience.[12]

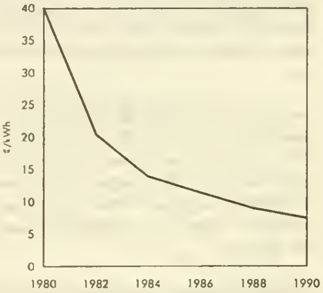
On a more technical level, industry advances in predicting rotor loads and rotor blade fatigue have allowed tighter margins in designing towers and turbines. As a result, less material and fewer replacement components are going into new wind units. Load predictions, as well as stronger, lighter materials, have allowed taller towers (50 meters as discussed above) to reach 20% to 30% increases in wind energy at only a 10% cost penalty. Advanced airfoils are capable of increasing annual energy capture by 10% to 30%, new rotor hub designs increase flexibility to lower rotor loads (and stress), and integrated drive trains improve efficiency. Also, "micrositing," i.e. careful placement of turbines, is significantly reducing wake losses and losses to terrain, such as tree stands.[13]

EXTERNAL COSTS AND BENEFITS

The best cases made for wind power today focus on perceived environmental benefits. Wind turbines create no by-products or emissions, save for the possibility of particulates kicked-up by turbulence. Wind turbines do not employ steam and, therefore, do not consume water resources or any other resource save for naturally occurring wind.

Nevertheless, arguments can be made for external costs. On one level, residents living near wind farms often complain of noise pollution and are joined by commuters and passersby in complaining about visual pollution. Some tourists driving through Palm Springs find the local wind farm fascinating while others find it an eyesore. On a different level, the Sierra Club and the Audubon Society have grown concerned about incidents of avian mortality at wind farms. Raptors and other birds have been flying into turbine blades with negative consequences. Although studies are still incomplete, the California Energy Commission has found that as many as 200 to 300 redtail hawks and 40 to 60 golden eagles, in addition to other species, die each year at Altamont Pass alone.[14] In fact, wind farms have been documented to act as both bait and executioner – rodents taking shelter at the base of turbines multiply with the protection from raptors, while in turn their greater numbers attract more raptors to the farm. Finally, wind turbines employing back-up generation on-site present emissions from natural gas or other energy resources employed.

FIGURE 2-12
COST OF ELECTRICITY USING WIND POWER PLANTS, 1980-1990



Source U.S. Department of Energy The Secretary's Annual Report to Congress 1990, DOE/S-0010P(91) (Washington, DC, 1991).

SUMMARY

The greatest arguments on behalf of wind power center on the fact that the technology generates no emissions. As discussed, certain environmental detriments are also present, particularly avian mortality, a problem for which the wind industry is struggling to find a solution. Other arguments on behalf of wind focus on the fact that wind power "fuel" is free and requires no production or human prodding. Also, wind provides the nation with a new secure energy resource.

While the wind industry has made tremendous strides in lowering wind powered production costs since 1980, typical current costs of 6.8¢ per kilowatt hour are still 25% to 50% higher than those for traditional energy sources. Drawbacks also exist in terms of capability, location, and capacity. Yet, these drawbacks only exist under unrealistic public expectations of the role that wind can play in serving America's energy needs. Wind cannot play a major role in meeting baseload demand, nor can it play any role in the majority of the country where adequate wind resources do not exist.

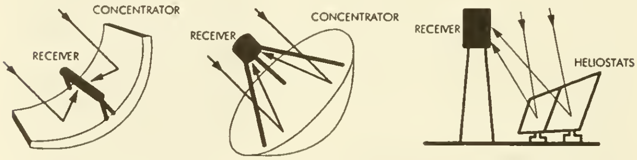
Solar Thermal

INTRODUCTION

Solar thermal technologies represent more than 90% of the total utility solar capacity installed in the U.S. All 354 megawatts of installed capacity were established during the 1980s.[1]

There are three well-developed solar-thermal technologies that can transfer solar energy into turbine-based electrical generation. Each is characterized by the type of mirrors that it uses. The first, *parabolic-trough system,* concentrates sunlight onto a thin receiver pipe at the focal point of the trough collector. The second, *parabolic-dish system,* uses tracking reflectors to concentrate sunlight onto a receiver system that acts as the "engine" or a heat "exchanger" and is located at the mirrors' focal points. The third technology is a *central-receiver system,* and uses heliostats (tracking mirrors) to reflect solar energy into a heat exchanger on a central tower. All of these technologies rely on four system components: receiver, collector, converter, and transport/storage. The overall performance of the system is therefore largely dictated by the efficiencies of the individual components. A brief discussion and working model illustration of each technology follows.

FIGURE 2-13
DIAGRAMS OF SOLAR THERMAL TECHNOLOGIES



PARABOLIC TROUGH COLLECTOR

CENTRAL RECEIVER SYSTEM

PARABOLIC DISH SYSTEM

Source Johansson, Thomas B., Henry Kelly, Amulya K.N. Reddy, and Robert H Williams. *Renewable Energy: Sources for Fuels and Electricity* Washington: Island Press, 1993

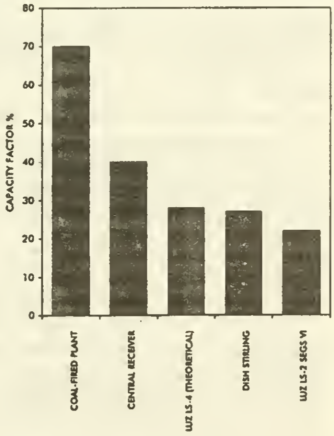
CAPABILITY

PARABOLIC-TROUGH SYSTEMS With close to 350 megawatts of in-place capacity adding to the grid, parabolic-trough systems represent the most tested and significant commercial solar technology in utility-grid applications. These systems use surface reflectors to concentrate sunlight onto a fluid-filled receiver tube located at the mirror's focus. The primary leader in this industry has been Luz Corporation, which built and operated nine solar electric generating systems (SEGS) since 1984 in Southern California.

The SEGS systems are characterized by hybrid generation, with natural gas co-firing representing approximately 25% of the total generating capacity. The first seven units are all 30 megawatts or less, while SEGS units 8 and 9 are 80 megawatts each. The increased size allows greater efficiencies and a decrease in production costs. However, decreases in overall production costs partially reflect the increased use of natural gas generation.

CENTRAL-RECEIVER SYSTEMS The 10 megawatt Solar One project demonstrated central-receiver technology on a utility scale. However, it utilized oil as the heat transfer medium and, thus, limited the ability of the unit to store thermal energy efficiently. This led to Solar One only being used as a peaking unit.[2]

FIGURE 2-15
CAPACITY FACTORS FOR SOLAR THERMAL TECHNOLOGIES

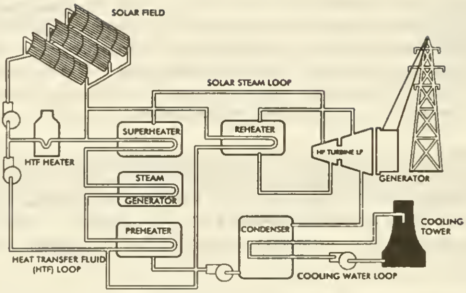


SOURCE: ARIZONA PUBLIC SERVICE, 1994.

Solar One is in the process of being dismantled and retrofitted into the Solar Two project at a shared DOE and utility consortium cost of $48.5 million.[3] Most of the components will be reused, including the heliostats, the turbine, and the generator. The major difference will be in the heat transfer medium as a new molten-salt mixture is utilized. This medium, which can contain heat efficiently for longer periods of time, will be heated to greater than 1,000°F. This technological advancement is expected to result in capacity factors approaching 60% which would allow greater dispatchability.

PARABOLIC DISH SYSTEMS Parabolic-dish systems concentrate solar energy onto a receiver located at the mirror's focal point. The receiver can be either a liquid that is heated and transported off to a generating site or a small engine that directly converts the concen-

FIGURE 2-14
DIAGRAM OF SEGS UNIT



Source: Johansson, Thomas B., Henry Kelly, Amulya K.N. Reddy, and Robert H. Williams. *Renewable Energy: Sources for Fuels and Electricity*. Washington: Island Press, 1993.

trated light into electricity. The most successful application of parabolic dish system is a dish-Stirling system. Dish-Stirling systems have been demonstrated in a range of 0.005-0.050 megawatts.[4] These units have exhibited the highest potential of the three solar thermal technologies in terms of total collected energy and peak solar concentration. However, this is also the least proven of the three solar technologies to date.

Most of the discussion that follows traces results from the SEGS units, as they represent the only solar thermal technology that has seen significant utility-scale application.

EFFICIENCY

In the case of solar thermal technologies, efficiency is measured as the ratio of net electric output versus total solar radiation received (i.e., insolation). Efficiency values for utility-grade central receiver technologies are limited to data collected from the Solar One project. An annual system efficiency of 7.4% was reported, with increases predicted in the Solar Two project as the thermal storage component is improved.[5] This value is expected to climb to at least 15% for the Solar Two project. Efficiency values for parabolic-dish technologies are generally highest among the solar thermal technologies averaging 23%, with new dish-Stirling engine systems exhibiting overall highest values in test modules of almost 30%. Parabolic-trough units average about 12% annually. This is a result of the inherent lower concentrating capability of solar trough technologies.

DISPATCHABILITY

All of the installed Luz units are configured to provide peaking dispatchability. If future SEGS plants are installed, they may be integrated with a combined-cycle system or utilize advanced collectors that generate steam directly (Luz LS-4 design) to increase baseload potential and dispatchability. Parabolic-dish systems, both distributed and independent (i.e., dish-Stirling), lack thermal storage capabilities and are used for peaking applications during daylight hours. Hybrid systems that employ co-firing during periods of no solar radiation may increase their dispatch position, provided costs are not prohibitive. The central-receiver demonstration, Solar One, was also used only as a peaking unit due to the lack of effective thermal storage by the oil-based heat transfer medium. Solar Two will be equipped with a molten-salt medium that will allow heat to be stored much more effectively. Combined with a gas co-firing process, Solar Two hopes to broaden the dispatching potential of central-receiver technologies.

LOCATION

Solar thermal technologies need open, unblocked access to the sun. Land requirements for parabolic trough and central receiver technologies are significant, and can range from five to ten acres per megawatt, respectively. Additionally, solar thermal technologies require substantial levels of daytime insolation in order to effectively produce electricity. Therefore, the ultimate range of potential sites is highly limited to regions that experience both a comparatively large number of sunny days and a high level of annual incident radiation.

Currently in the U.S., all solar-thermal electric generating facilities are located in the Southwest, where these conditions exist.

MODULARITY

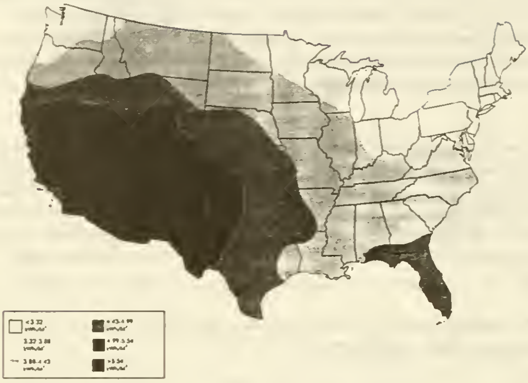
Parabolic-trough and central receiver type solar thermal applications do exhibit some characteristics of modularity, while parabolic-dish engine systems are highly modular. In the case of central receiver plants, attenuation (i.e., air turbulence from heat) is the upper size limiting factor, with reflectors becoming ineffective due to an inconsistent air-transfer medium at distances greater than 2 kilometers from the receiver.[6] Attenuation, therefore, places a theoretical capacity limit of about 1,000 megawatts on central receiver station systems, although this is well beyond the range of technically proven ability.

Parabolic-trough systems are modular in design, but consume a substantial amount of space. Land availability is likely to also limit the upper size range of these systems. Parabolic-dish systems have modular collector and receiver units that can function as part of a system or independently. They are currently being produced in 0.005-0.025 megawatt units.

COSTS

Significant cost reductions have occurred for solar thermal technologies, given that 1980 production costs of 60¢ per kilowatt hour were reduced to about 12¢ to 20¢ per kilowatt hour by 1990.[7] While solar thermal plants are capital-intensive, they have low operating costs due to the free nature of fuel costs, excluding hybrid fossil-fuel costs for supplemental electric generation. Collectors are the most expensive component, and collector efficiency can be the most critical factor in determining overall cost-competitiveness.

FIGURE 2-16
AVERAGE DAILY SOLAR RADIATION
(ON A HORIZONTAL SURFACE)



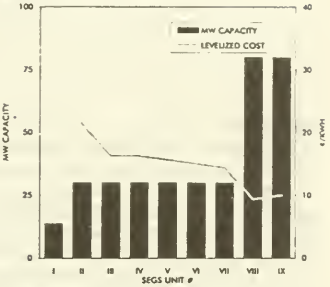
Source NREL "Profiles in Renewable Energy: Case Studies of Successful Utility-Sector Projects." Golden, CO., 1994

RDI calculated levelized production costs for a hypothetical, new solar thermal unit at between 13.4¢ to 26.3¢ per kilowatt hour (not including the cost of gas-fired backup units). These numbers are based on an 80 megawatt parabolic-trough operating at a 40% annual capacity factor and located in the Mountain states. Accelerated depreciation has been included. Variance in these costs result primarily from alternate financing assumptions, although a full explanation of the methodology behind these calculations is available in Section IV and the Technical Appendix of this study.

Parabolic-trough systems built in the 1980s have costs based on the power-purchase agreements of that era. They have been largely dependent on tax incentives, special contract agreements (including California's ISO4), and high fossil fuel prices—factors that have diminished significantly since the 1980s. Even though the SEGS units showed advancements in efficiency, availability, and overall unit competence, the economic climate was not right for the technology to be realized by the late 1980s. Ultimately this led to the Luz Corporation's bankruptcy in 1991.

In order for central receiver plants to approach economic viability in today's market, plant capacity must be large, in the order of 100 to 200 megawatts, with capacity factors ranging from 40% to 60%.[8] As the scale of these projects increase, there is likely to be a non-linear increase in savings in the areas of O&M and thermal efficiency. At present, it is difficult to predict production costs for this type of technology as there are insufficient data. DeLaquil, et. al., predict that by the time the first 100 megawatt plant is constructed production costs will, optimistically, range from 8-17¢ per kilowatt hour.[9]

FIGURE 2-17
SEGS UNIT ADDITIONS VS. COSTS
IN 1993 $



Source Johansson, Thomas B., Henry Kelly, Amulya K N. Reddy, and Robert H Williams. *Renewable Energy Sources for Fuels and Electricity* Washington Island Press, 1993.

Parabolic-dish Stirling systems are in the early stages of their testing phase and will need to be implemented on a larger scale before adequate cost data can be collected. Current production costs are well above 30¢ per kilowatt hour and beyond the range of viable options for baseload capacity (on a commercial scale).

EXTERNAL COSTS AND BENEFITS

Almost all of the minor external effects of solar thermal electricity producing systems come from manufacturing processes and land requirements. Once on-line, there are no significant emission contingencies, apart from the emissions of fossil fuel co-firing. Siting criteria include high solar radiation, low biological diversity, and aesthetic value. Unfortunately, most of these sites occur in the desert, where soils are fragile and highly susceptible to erosion. A unique concern associated with solar thermal technology is the possibility of misguided or errant reflected light. Stringent safety control methods are necessary in the installation and operation of solar thermal technologies.[10]

INCENTIVES

Solar energy technologies have enjoyed the most rigorous tax and regulatory incentives of nearly all possible electric generating positions. The passage of PURPA initially sparked growth in the field, while California PUC renewable-friendly contract arrangements (i.e., ISO2 and ISO4) insured high-priced contract stability and made solar-thermal technologies a less risky endeavor which drew financial support from private investors. Also, all solar technologies have been given a 10% federal investment tax credit, and plants that started construction before 1995 are given rapid depreciation and 1.5 ¢ credit for each kilowatt hour of delivered energy.

SUMMARY

Several factors have precluded the expansion of solar thermal technologies into widespread commercial applications. Specifically, prices for fossil fuels have fallen significantly from the 1980s at the same time that EPAct has increased competition between utilities through deregulation. The tax and regulatory structures faced by utilities also inhibit their participation in new projects. Despite advances in efficiency and cost, solar thermal technology has not been able to keep pace with the market. In the end, it is doubtful that solar thermal technologies will displace much, if any, traditional generating capacity in the U.S. over the next 20 years.

Solar Photovoltaics

INTRODUCTION

In 1994, over 400 utility-sponsored Photovoltaic (Pv) sites provided close to 14 megawatts of capacity for the grid. While most of these utility projects are very small and non-cost-effective (less than 0.001 megawatts) in comparison to traditional generating technologies, some solar advocates feel that Pv economics will eventually be pushed over the threshold into market viability. This optimism is driven by the increasing production of consumer Pv cells (e.g., those used in watches and calculators) and a growing demand for stand-alone Pv systems in developing countries. With the major Pv manufacturers ramping up their output to meet growing worldwide demand, industry advocates reason that it is possible that one of several new technologies being pursued for the consumer market will translate into a utility grade, central generation application.

In late 1994, Enron Corporation announced plans to build a 100 megawatt Pv power plant in the Nevada desert. Citing such factors as increased savings through bulk production of power cells, new and proprietary technology that increases cell efficiency, interest-free bond financing, plant site access to Federal transmission lines and guaranteed long-term power purchasing by the U.S. government, Enron suggests it can -- for the first time on a large scale for Photovoltaics -- profitably deliver electricity. However, Enron's claims have been met by skepticism, even within the ranks of renewable advocates who have adopted a "wait and see" stance.

TABLE 2-2
UTILITY-GRID PV PROJECTS IN THE U.S., 1994

SYSTEM	STATE	LOCATION	UTILITY	KW_{ac}*	NO. OF UNITS	TOTAL CAPACITY (MW)
CARISSA PLAINS #1	CA	CARISSA PLAINS	PG&E	500	9	4.50
SMUD PV1	CA	SACRAMENTO	SMUD	1,180	1	1.18
SMUD PV2	CA	SACRAMENTO	SMUD	1,170	1	1.17
HESPERIA (LUGO)	CA	HESPERIA	SCE	500	2	1.00
CARISSA PLAINS #10	CA	CARISSA PLAINS	PG&E	700	1	0.70
KERMAN (PVUSA)	CA	KERMAN	PG&E	500	1	0.50
SMUD RESIDENTIAL	CA	SACRAMENTO	SMUD	4	108	0.43
PVUSA APS	CA	DAVIS	PG&E	400	1	0.40
GEORGETOWN	DC	WASHINGTON	PEPCO	300	1	0.30
		ALL OTHERS		3,345	255	3.56
			TOTAL		380	13.75

*Kilowatts-Alternating Current

Source: PVUSA

CAPABILITY

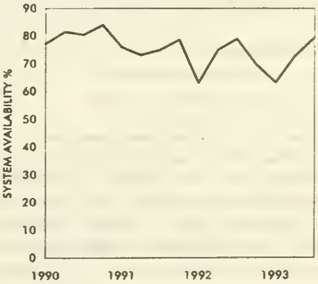
Unlike most other technologies that convert an energy resource into heat to move a turbine, solar Pv cells generate electricity directly from the sun. The capability of photovoltaics is therefore a function of how well incident radiation, i.e., insolation, can be translated into electrical current. This dynamic presents a unique combination of attributes. For example, Pv electric generation is available only while there is appreciable incident solar radiation, making this an intermittent application. On the other hand, Pv's frequent correlation of peak availability with peak demand does offer the technology a potential place in the dispatch order.

PvUSA (Photovoltaics for Utility Scale Applications), a consortium of over 80 utilities testing Pv applications, defines Pv availability as the percentage of daylight hours supplying net power to the utility.[1] This definition takes into consideration poor sunlight days and down-time, making it a conservative assessment of availability factor.

PvUSA conducted a five-year study of emerging module technology that analyzed the latest Pv cells from the five largest vendors. In that study, availability factors ranged from 60% to 90%, with a mean of about 81%. This test was undertaken in locations characterized by a high level of annual insolation, Davis, California, and Maui, Hawaii.

Of the six Pv modules tested, all but one were mounted at a fixed angle, which is less costly than a tracking module due to the equipment and operating requirements of tracking units. All five fixed modules showed insignificant seasonal fluctuations in availability, while the tracking Pv unit exhibited a much lower availability in winter months and several down periods due to technical difficulties. Availability values were most affected by failures of invertors and other electrical conversion devices, rather than module failures.[2] Other important results from this experiment showed that the solar cell efficiency dropped 2%-3% per year and that overheating of the cell reduced overall performance.

FIGURE 2-18
EMT ARRAY DAYLIGHT SYSTEM AVAILABILITY



Source. Townsend, Tim Endecon Engineering: "Emerging Photovoltaic Module Technologies at PVUSA: A Five-Year Performance Assessment." San Ramon, CA, 1993.

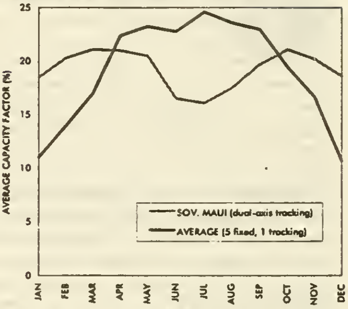
Annual capacity factors for photovoltaic technologies reflect the technology's appropriateness in a peaking position, averaging 19% in 1994. Nevertheless, some tracking Pv module units that follow the sun across the horizon to maximize incident radiation, have shown capacity factors upwards of 35%.[3]

A final indicator of capability is efficiency. Unlike traditional technologies, which base efficiency on a heat rate, Pv efficiency is defined as total DC electric output divided by the total solar energy input and varies by technology type. Three types of solar Pv technologies being pursued today: thin film, polycrytalline silicon, and amorphous silicon. A-silicon Pv's have relatively low efficiencies, while crystal-silicon Pv's exhibit efficiencies between 10% and 12%.

MODULARITY

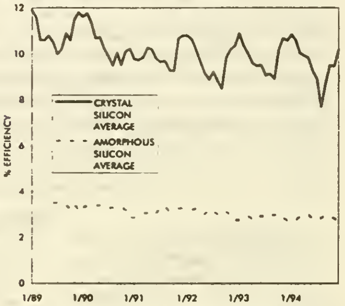
There are several levels for Pv utility-grid applications, with the concept of modularity existing at the heart of the issue. Pv's are entirely modular. They are formed into discreet solar cells and placed adjacent to one another on a panel. These panels can be linked together to virtually any size, depending on the demand load. The first level is a central Pv generation system. Under this scenario, thousands of solar arrays are linked together to create a utility scale generating unit. Several large pilot programs following this design have been installed in the U.S., including a 2 megawatt system by Sacramento Municipal Utility District (SMUD).

FIGURE 2-19
CAPACITY UTILIZATION VALUES FOR SIX EMERGING MODULE TECHNOLOGIES



Source: Townsend, Tim. Endecon Engineering "Emerging Photovoltaic Module Technologies at PVUSA: A Five-Year Performance Assessment." San Ramon, CA, 1993.

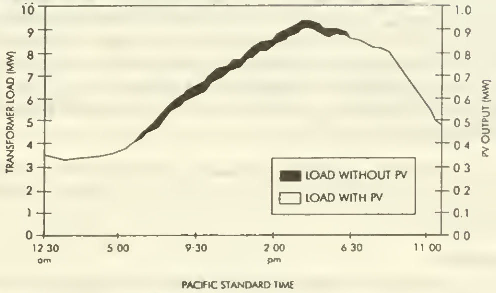
FIGURE 2-20
EMT ARRAY MONTHLY DC EFFICIENCIES



Source: Townsend, Tim. Endecon Engineering. "Emerging Photovoltaic Module Technologies at PVUSA: A Five-Year Performance Assessment." San Ramon, CA, 1993.

In addition to the conventional supply approach, a paradigm shift for Pvs is generation at the demand site. Thousands of individual Pv systems mounted on consumers' homes could, and in some cases in the U.S. already do, provide electricity to the individual consumer, displacing grid-provided energy. Excess production can then be sold back to the grid during maximum solar incidence hours, while off-peak hour electric budgets can be met by traditional utility provided methods. SMUD recently fielded a program that allows customers to opt for a 2 kilowatt (or 0.002 megawatt) Pv unit to be installed on their homes for a monthly surcharge of $15. Due to a high level of interest for this program, the municipality is unable to meet customer demand.

FIGURE 2-21
TRANSFORMER LOAD AND PV OUTPUT ON PEAK DAY
PG&E KERMAN GRID SUPPORT PROJECT



Source: First World Conference on Photovoltaic Energy Conversion, December, 1994

One of the major advantages of this concept results from the dramatic loss of transmission and distribution costs (or losses), which can be greater than 20%, depending on relative distances traveled.[4] Needless to say, several obstacles preclude rapid advancement of this scenario. There must be development of uniform utility interconnection standards, including standardized inductors to insure quality specifications for the grid. Also, there would be a need to address secondary concerns such as the implementation of net metering and effective and fair utility "buy-back" structures which are based loosely on the avoided cost that is set by the state PUC.

One of greatest areas for Pv growth is in the transmission and distribution aspect of utility service. Transmission and distribution assets represent up to 40% of a utility's total capital investment.[5] Results from the PG&E Kerman grid-support project indicate that Pv systems can effectively reduce peak load on a substation facility. By installing Pvs at sites lacking adequate grid capacity, utilities may avoid expensive line or substation upgrades. In addition, supplemental load support serves to reduce the overall operating temperature of the substation and prevents rapid degradation of expensive electrical components. While PG&E's operating results showed potential for distributed Pv applications, economic benefits were less than expected.[6]

LOCATION

In considering location, two separate issues must be addressed: solar resource availability and economic distribution. At present, most Pv-grid applications in the U.S. occur in areas that receive a relatively high level of solar radiation, though it is important to note that Pv's can operate more independently of insolation levels than solar thermal technologies. A study by NREL found that Pv capability is highly correlative to utility demand loads and that locations not usually targeted for Pv applications (i.e., the Mid-Atlantic) sometimes offered the highest load-matching characteristics.

One of the major factors for an economically viable Pv station is that it be near the grid. Long transmission lines greatly add to the overall delivered price of the electricity and contribute to line losses. In an effort to save costs, utilities are examining the benefits of installing remote Pv systems to offset large capital-intensive upgrades at transformers and substations. PG&E has tested the viability of this concept and has found that Pv systems can potentially produce cost-effective savings given: (1) a high correlation between Pv electrical output and local distribution peak load; (2) low expected load growth in that locale; and (3) sufficient land available economically.[7]

In 1991, over 90% of all Pv applications were used to provide electricity at remote sites, such as rural homes, pumping stations, communication and highway lighting installations and consumer products.[8]

COSTS AND BENEFITS

Pv costs can be assessed by examining four cost criteria: (1) total cost of the Pv module; (2) a Pv's efficiency factor in converting sunlight into electricity as well as its capacity factor over a supply period; (3) installation, O&M, and other embedded costs; and (4) lifetime of the system/total expected electricity production over a supply period.

RDI calculated levelized production costs for a hypothetical, new solar Pv central generating station at between 16.1¢ and 35.4¢ per kilowatt hour. These numbers are based on a 50 megawatt flat plate Pv unit located in the West. Accelerated depreciation has been included. Variance in these costs result primarily from alternate financing assumptions, although a full explanation of the methodology is available in Section IV and the Technical Appendix.

Remote Pv applications entail different costs which are generally considered in comparison to the cost of installing new lines or upgrading substations. In some instances, the cost of remote Pv's can reach a magnitude five times greater than standard consumer electric rates and still be justified. However, a study recently completed by Minnesota Power evaluated the economic viability of several options in providing off-grid customers with electricity. The conclusion was that installation of a distribution line connection was the lowest first-year cost (with a levelized cost of $0.36 per kilowatt hour) by a significant margin over competing alternatives, noting that all new customers would be located within a mile of an existing grid connection.

A customer using only solar Pv was the highest first-year cost option at a levelized cost of $58.35 per kilowatt hour. In fact, solar Pv was identified as an economically viable option only when used in concert with a propane generator and when the transmission line extension would be greater than 5 to 8 miles. These conclusions coincide with evidence that most remotely sited Pv units are located in Western states that are characterized by larger distances from the grid and a more variable and challenging topography that increases the line extension costs. It is, therefore, important to note that distance from the grid is likely to be the limiting factor in identifying future off-grid customers.[9] The overall implication is that the viability of Pv remote applications must be examined on a case-by-case basis.

Costs for Pv technologies have been characterized by a punctuated evolution, with distinct technological advances resulting in lower costs. First and foremost, Pv cell efficiency advancements greatly reduce the overall price of electricity produced. On any cost analysis for a Pv system there exits an efficiency line of demarcation that, when crossed, pushes Pv into the economically viable range. Traditionally, efficiencies for thin-film Pv have hovered between 3% to 5%, while new a-silicon and poly-silicon cells average around 10%. Laboratory tests of new technologies are pushing the 20% efficiency level, which could be enough to make them an economically attractive option in several grid applications.[10]

EXTERNAL COSTS

Pv cells present a closed generating system that neither emits pollutants nor consumes fuel or water. Environmental concerns do exist, however, with regard to the chemical components of Pv technology and land requirements.

The production of Pv cells can be a potentially hazardous process. While many of today's commercially produced cells are silicon based and non-hazardous, some of the technologies utilize hazardous chemicals, like gallium arsenide and cadmium sulfide. Furthermore, the efficiency of the Pv manufacturing process tends to be very low, resulting in a relatively large amount of residual solid wastes.

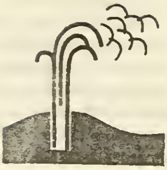
Land requirements for Pv's are driven by their modular nature. For a large-scale, central producing project, land requirements will vary widely by the relative efficiencies of the Pv technology that is being installed and by the average annual insolation. For some distributed utility applications, such as utility-installed homeowner rooftop mounted Pv units, land requirements are displaced by the existing roof structure, assuming that there is sufficient exposure to daytime radiation.[11]

SUMMARY

Pv technology offers several benefits to utilities. First and foremost, the technology creates only a marginal impact on the environment. Manufacturing processes and land requirements are certainly areas of concern, but are balanced by the fact that Pv cells consume no fuel (outside of solar radiation) or water and generate no emissions. Solar resources occur naturally and can serve as a hedge against imported sources of energy.

Pv limitations relative to central generation applications include scale (a function of land requirements), location, intermittent availability, and cost. Of these, cost is the most limiting, with Pv economics at least ten times more expensive than competitive technologies. Therefore, application of Pv technology in a central generating mode is currently inappropriate. Application in a remote configuration, however, is showing some promise because the technology competes against distribution line construction costs rather than against electric generation market prices. In that light, public expectations for Pv technology must be recalibrated to fit its true potential.

Geothermal



INTRODUCTION

The town of Lardello, Tuscany, Italy, has been producing electricity from geothermal resources almost continuously since 1904, and the Italians are credited with developing the first dry steam generators. Because of low fossil fuel prices, it wasn't until 1958 that New Zealand became the second country to produce electricity from geothermal resources, followed by the United States in 1960.[1] Today, about 6,000 megawatts are installed around the world, with more than 2,700 megawatts of capacity in the U.S. alone (90% of that amount in California, with the remainder in Utah, Nevada and Hawaii).[2]

The U.S. geothermal industry has announced plans for an additional 682 megawatts of geothermal power projects through the year 2000. Included in these plans would be 22 new plants and 3 plant expansions at existing sites. The geothermal industry believes that 57% of the capacity plans are non-speculative based on signed power agreements and strong utility commitment. The remaining 43% are speculative, but included in the total due to optimistic assessments based on corporate/utility sponsorship, local support, RFP processes, and ongoing negotiations.[3]

CAPABILITY AND AVAILABILITY

The natural resource exploited in geothermal electricity generation technology is hydrothermal, which consists of heated water, liquid and vapor. Three other geothermal resources, hot dry rock, geopressure, and magma, also exist but are not utilized commercially due to lack of an appropriate technology. Unlike most other naturally occurring energy phenomena, geothermal energy is neither seasonal nor intermittent and is, thus, ideally suited to a utility baseload dispatch position. In fact, the U.S. Department of Energy reports that geothermal annual capacity factors average 90%, indicating not only a robust capability, but also high availability.[4]

TABLE 2-3
INSTALLED GEOTHERMAL CAPACITY

NATION	MW 1980	1990
CHINA	0	21
COSTA RICA	0	0
DOMINICA	0	0
EL SALVADOR	95	95
FRANCE	4	4
GREECE	0	0
GUATEMALA	0	2
ICELAND	41	45
INDONESIA	32	142
ITALY	459	545
JAPAN	215	215
KENYA	45	45
MEXICO	425	700
NEW ZEALAND	167	283
NICARAGUA	35	35
PHILIPPINES	891	891
PORTUGAL (AZORES)	3	0
ST. LUCIA	0	0
THAILAND	0	0
TURKEY	21	21
USA	1,444	2,770
USSR	11	11
TOTAL	**3,888**	**3,828**
TOTAL W/O USA	**2,444**	**3,058**
% INCREASE		50
% INCREASE W/O USA		25

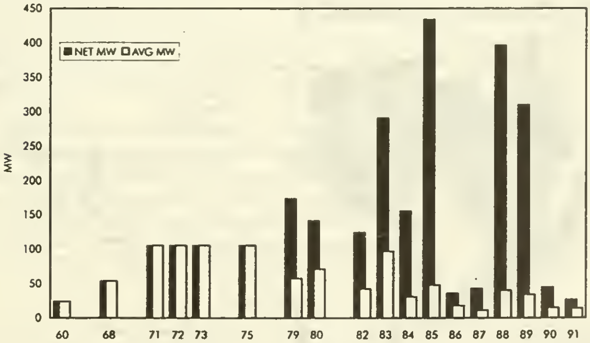
Source: Geothermal Resources Council "Bulletin" July/August, 1990

In terms of scale, average geothermal plant size has been trending downward since the mid-1970s. Prior to that, plants based on 55 megawatt turbines and multiples of 55 megawatts were an industry standard, with some development of turbines as large as 138 megawatts. Passage of PURPA in 1978 brought NUG developers into the industry along with QF requirements of a maximum 80 megawatt plant size.

NUG geothermal projects quickly outnumbered utility projects and drove down the average plant size. In recent years, the trend toward even smaller plant size is driven by state policy as well as the risk-aversity of project developers and financiers in the face of new geothermal fields and less favorable economics. In 1990 and 1991, plant size for new capacity averaged about 15 megawatts.[5]

While this trend toward smaller plants may entail benefits in terms of increased availability and modularity, individual plant capability has suffered. The technology's ability to serve in a baseload position remains intact, yet the ability of an individual plant to contribute significantly to overall baseload supply has been greatly diminished. Indeed, average plant size in 1990-1991 was only 15% of the average plant size in the early 1970s. Further, average size during that earlier period, 106 megawatts, is itself only a fraction of the average capacity of traditional baseload technologies.

FIGURE 2-22
GEOTHERMAL CAPACITY ADDITIONS AND AVERAGE PLANT SIZE, 1960-1991



Source. Alex Sifford, Oregon Department of Energy, Geothermal Databases Summary Report, Geothermal Resources Council "Transaction," Vol. 16, Oct. 1992.

MODULARITY

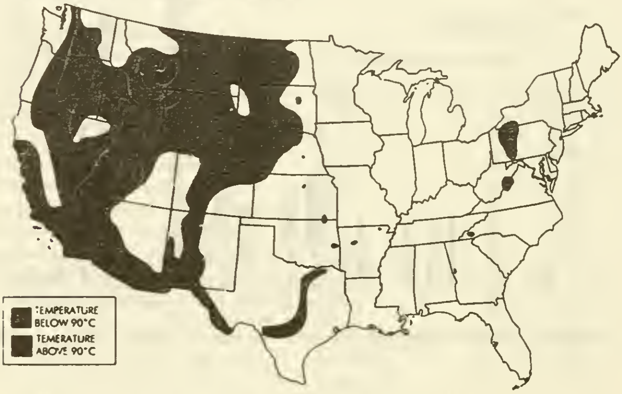
Smaller average geothermal plant size has enhanced the technology's positive aspects related to modularity. As noted above, smaller unit size is facilitating project development by assuaging the concerns of both developers and financiers. While this increased modularity has reduced the economies of scale benefits found in larger projects from the 1970s, it has improved availability. Where one 55 megawatt turbine going down would cut off all generation, a group of four 15 megawatt plants with one turbine down would see less than one-third of their capacity cut off. Nevertheless, as with all modular technologies, smaller unit size reduces the technology's overall capability and importance in meeting overall demand.

LOCATION

Location is the fundamental drawback in geothermal electricity production. Recoverable resources are available primarily in California, Nevada, Utah, Oregon, Washington, Alaska, and Hawaii, with smaller pockets occurring in New Mexico, Arizona, Wyoming, Idaho, and Montana. In these states, hydrothermal resources are present at temperatures above 194° Fahrenheit, which is generally the cut-off point for economic recovery.

Binary cycle geothermal plants, a technology representing 10% of current geothermal capacity, operate best at temperatures below 380°F (193°C), with some plants producing electricity at temperatures as low as 150°F (65°C), albeit uneconomically.[6] Given that the vast majority of hydrothermal resources in the United States are below 194°F, improvements in binary cycle plant technologies are critical to the future advancement of geothermal electricity production in this country.

FIGURE 2-23
KNOWN AND POTENTIAL GEOTHERMAL RESOURCES

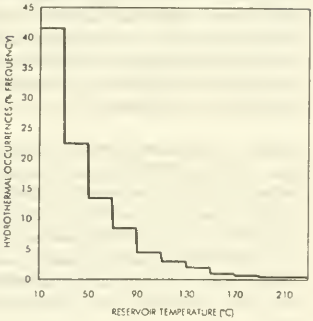


Source NREL "Profiles in Renewable Energy: Case Studies of Successful Utility-Sector Projects." Golden, CO., 1994

Another locational aspect of geothermal technology is that resources tend to exist in remote areas, often in national parks. The largest utilized geothermal field in the U.S., The Geysers, is located in a remote part of northern California. To transport electricity from this area, California's electric utilities had to invest significant capital into new transmission lines to connect The Geysers to demand centers in San Francisco and Los Angeles.

Such an investment can pay for itself given adequate economies of scale. However, as discussed earlier, the trend in geothermal development has been toward smaller projects and reduced economies of scale. Therefore, development in remote geothermal fields may be constrained by an inability to finance transmission access.

FIGURE 2-24
FREQUENCY OF OCCURRENCE VS. TEMPERATURE OF GEOTHERMAL RESOURCES



Source Reed, 1982

COSTS AND INCENTIVES

There are four geothermal technologies commercially available today: Dry Steam, Single Flash, Double Flash, and Binary Cycle. Dry Steam extracts naturally occurring steam from a well and runs it directly through a turbine. Flash plants pull hot water from a well into a separator tank where lower pressure allows a portion of the water to "flash" into steam and run through a turbine.

Double Flash plants have efficiencies superior to Single Flash plants because they repeat the flashing process to take maximum advantage of the hydrothermal energy. Binary Cycle technologies run hydrothermal fluids in one loop and a power fluid (isobutane or ammonia) in another. These two loops align in a heat exchanger where the power fluid is vaporized and then run through a turbine.[7] With a virtual end to development of projects at The Geysers, which is suited to Dry Steam, the majority of new projects in the U.S. are employing Double Flash or Binary Cycle technologies.[8]

Based on these two technologies, levelized production costs for geothermal electricity production range from 7.3¢ to 9.8¢ per kilowatt hour for a Double Flash plant design based on a 24 megawatt unit. Variations in the costs arise mainly from sensitivities dealing with discount rates. These costs include consideration for a 10% investment tax credit and a 1.5¢ per kilowatt subsidy provided under EPAct. A full explanation of RDI's levelized production cost estimates is contained in Section IV and the Technical Appendix of this study.

As with any other power plant, actual production costs will depend on project specific factors. For example, project capital costs will be strongly affected by the characteristics of the geothermal resource. Specifically, scaling and corrosion properties will have a direct impact on material selection and on the size of heat exchangers in a Binary Cycle design. Further, higher resource temperatures create higher plant efficiencies and lower costs. In Binary Cycle designs, costs are 10% lower at 300°F than at 250°F. Chemistry characteristics, as well as other factors such as well depth, vary to such an extent that general cost relationships are not available.[9]

The geothermal industry faces much greater cost pressure today than it did in its early years. At the time PURPA came into law, oil prices were high and expected to continue growing. California relied heavily on oil and thus contemplated very high long-term avoided costs when it issued ISO4. Utilities and geothermal developers signing power supply agreements under ISO4 therefore locked into fixed pricing schedules that started at 5¢ per kilowatt hour and are escalating to 15¢ per kilowatt hour by 1999 (depending on actual agreement and start date). Meanwhile, avoided costs in California have dropped from 4¢ to 7¢ per kilowatt hour at the time of signature to 2¢ to 3¢ per kilowatt hour today.[10]

For plants built in California during the 1980s (the vast majority of all U.S. geothermal development during that period took place in California), ISO4 acted as a large subsidy that will disappear upon expiration of their power supply agreements, which generally have a base term of ten years. Geothermal industry concern over the "11th Year" (i.e., the year that plants built under ISO4 contracts will have to compete on the open power market) belies not only a grave concern over the economic feasibility of existing plants, but also the future for new plants. In fact, an article in the Geothermal Resources Council *Bulletin* predicts that geothermal power developers will "fare poorly" in an environment where utilities award power contracts "based on costs only."[11]

EXTERNAL COSTS AND BENEFITS

As with solar and wind power, the greatest arguments for geothermal power center on the environmental benefits associated with emissions-free generation. In fact, Dry Steam technologies emit small amounts of carbon dioxide (CO_2), nitrogen oxide (NO_x), and sulfur dioxide (SO_2), as do Flash technologies which also release hydrogen sulfides and must protect employees against mercury and arsenic exposure. Hydrogen sulfide is a toxic gas which may cause eye damage at 50 parts per million volume. Concentrations at U.S. geothermal sites range from 0.18 ppmv to 60.7 ppmv.[12] Binary Cycle plants, which represent only 10% of current capacity, do not expose geothermal resources to the environment and, thus, produce no emissions, save for some hydrocarbon emissions from the power fluid.[13]

Another strong argument for geothermal energy rests on its status as a renewable resource. Again, the perception is somewhat misleading given that geothermal resources degrade once exploited. For example, the most exploited geothermal field, The Geysers, had about 1,800 megawatts of installed capacity in 1992, but only 1,250 megawatts of operating capacity due to steam shortages. In fact, experts predict output from The Geysers to decline 10% annually during the 1990s, resulting in 700 megawatts of lost capacity between 1990 and 2000. Industry is attempting to mitigate these losses through better reservoir management and increased power plant efficiency.[14]

Other benefits of geothermal include limited land use. The Worldwatch Institute calculates that geothermal plants occupy as little as 0.1 acres per gigawatt hour versus 0.3 for wind (turbine occupied land only), 0.8 for solar Pv, and 0.9 for solar thermal technologies.

On the whole, geothermal electricity generation produces little or no emissions or byproducts, requires little dedicated land, and consumes a naturally occurring resource. Although not a renewable source of energy in the truest sense, geothermal resources are relatively unexploited at this time.

SUMMARY

The most difficult hurdles for geothermal energy are capability and cost. The two are intertwined to a degree, since the economic risk involved in developing geothermal projects is forcing smaller projects and thus lower capability. Even as an industry, geothermal plants generated only 25% of all U.S. renewable energy (excluding hydroelectric) in 1990, where renewables as a whole accounted for only 2% of total U.S. electricity generation. As a result, utilities cannot be expected to significantly displace more traditional sources of baseload capacity with geothermal. In fact, capacity losses through degradation of resource and economic failure in the 11th Year for ISO4 projects will challenge the industry to maintain its current position.

Biomass Combustion

INTRODUCTION

The concept of biomass as an emerging energy technology is somewhat ironic, given that wood served as mankind's primary source of energy until the early part of this century when coal and oil took over. Today, as the result of energy security and environmental issues, there is a renewed interest in biomass. Fuel sources used for grid-connected biomass electricity generation include lumber and agricultural industry "residue," consisting of wood chips, rice hulls, nut shells, bagasse, grape vines, hog fuel (an industry term for lumber waste), and other such waste. While Municipal Solid Waste (MSW) and Landfill Gas (LFG) are also considered biomass technologies, they are discussed in a separate section of this study due to certain issues unique to those technologies. Therefore, "biomass" in this section will address only fuels derived from agriculture and lumber.

Installed U.S. generating capacity based on biomass fuels stood at 7,415 megawatts in 1992, with more than 81% of that figure consisting of non-utility generation from wood and lumber industry residues.[1] In fact, biomass is the largest of all grid-connected renewable energy sources, representing almost half of all installed U.S. renewable capacity (not including traditional hydroelectric).[2] In many senses, biomass is hardly exotic or even an "emerging" technology. Biomass boilers are not very different from coal boilers, and the idea of burning agricultural waste is not new. What is radical, however, is the concept of cultivating crops, and even forests, for the primary purpose of fueling biomass boilers. The rationale for embarking on such a program is detailed in the following discussion.

TABLE 2-5
SOURCES OF WOOD WASTE

- **HARVESTED WOOD**
  - -LOGGERS
  - -CHIPPERS
  - -LANDCLEARERS
  - -DEVELOPMENT COMPANIES
  - -FOREST & PARK AGENCIES
- **MILL RESIDUE**
  - -SAWMILLS
  - -PLANING MILLS
  - -FLOORING MILLS
  - -PULP & PAPER MILLS
  - -BOAT BUILDERS
  - -FENCE MAKERS
  - -STRUCTURAL MEMBER MILLS
    - TRUSSES TIMBERS ARCHES
  - -CONTAINER MANUFACTURERS
    - CABLE SKIDS BARRELS
    - REELS BORES BASKETS
    - PALLETES SHOOK TURS
  - -RECONSTITUTED BUILDING PRODUCTS
    - FLAKEBOARD
  - -COOPERAGE MILLS
  - -CABINETMAKERS
  - -VENEER & PLYWOOD MILLS
  - -LOG CABIN MANUFACTURERS
  - -PARTITION MANUFACTURERS
  - -FURNITURE MAKERS
- **PALLET WASTE**
  - -FURNITURE MOVERS
  - -COMMON CARRIERS
  - -HARBOR & PORT AUTHORITIES
  - -DISTRIBUTION COMPANIES
  - -MAJOR DEPARTMENT AND RETAIL STORES
  - -SHIPPING LINES
  - -WAREHOUSES
- **CONSTRUCTION AND DEMOLITION WOOD**
  - -GENERAL CONTRACTORS
  - -ROOFING CONTRACTORS
  - -CARPENTERS
  - -PIER CONSTRUCTION
  - -DEMOLITION CONTRACTORS
- **OTHER WOOD WASTE**
  - -RESIDENTIAL YARD WASTE
  - -ORCHARDS & NURSERIES
  - -LANDSCAPING BUSINESSES
  - -UTILITY COMPANIES

Source: EIA, "Estimates of U.S. Biomass Energy Consumption 1992."

CAPABILITY AND AVAILABILITY

As noted above, biomass boilers are not very different from coal boilers, which means that biomass technology can be controlled and dispatched on the grid with great reliability in a baseload or intermediate position. Overall capability is limited to a degree by the intermediate size of biomass boilers, 10 to 100 megawatts, although this is larger than most other renewable technologies on a unit basis.[3] Optimum biomass unit size is 50 megawatts based on an economic rule of thumb that fuel must be supplied from within a fifty mile radius of the plant.[4] Further, given the fact that biomass boiler technology is familiar and proven, availability is generally high. There are, however, significant exceptions that may greatly affect the capability and availability of biomass. These exceptions all relate to the unique characteristics of the various fuel sources and include availability, variability, handling, and heat conversion.

The greatest limitation on biomass generation comes from the fact that most biomass boilers are dependent upon a parent industry for their fuelstock. In this regard, the capability of some boilers is tied to the seasonality of a particular crop and even to weather conditions, such as floods and droughts. The capability of boilers burning wood chips and other lumber waste can likewise be constrained given a poor market for lumber products. For example, the closure of a Weyerhaeuser plant in Wisconsin in the early 1990s deprived Northern States Power's French Island wood-fired plant of 15% of its fuel supply. Due to these fundamental drawbacks, developers have put forth the concept (as yet to see commercial application) of cultivating crops for the sole purpose of fueling a biomass power plant. Such a scheme would allow the power plant to cultivate crops specifically designed for combustion and to avoid the dictates of an extraneous agricultural market.

Two types of crops, short rotation woody crops (SRWC) and herbaceous energy crops (HEC) currently lend themselves to dedicated fuelstock cultivation. The first type, SRWC, is basically a category of trees including poplar, black locust, sycamore, sweetgum, willows, and silver maple, among others, that mature within five to ten years or less.[5] New York State Electric & Gas is co-funding an experiment at the State University of New York (SUNY) at Syracuse in which scrub willows have been developed that grow as much as one foot per month, or three times as fast as wild willows. Further, where harvests of wild willows yield one ton per acre, the SUNY trees yield nine tons per acre.[6] A study by Minnesota Power has even assumed 40 tons per acre, based on hybrid poplars.[7]

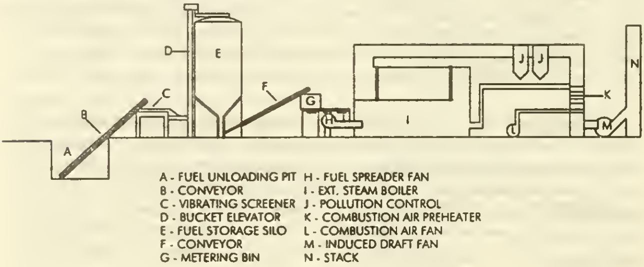
The second type of crop, HEC, consists of three subcategories: thin-stemmed perennials, thick-stemmed perennials, and thick-stemmed annuals. Thin-stemmed perennials consist of wheatgrasses, smooth bermudagrass, bermudagrass, big blue stem, and switchgrass. All have demonstrated erosion control capabilities and are useful in rotation with crops intended for agricultural markets. Thick-stemmed perennials, such as sugar cane, energy cane, and napier grass, as well as thick-stemmed annuals, such as corn, sorghum, and sudangrass, require more intense management than the thin-stemmed perennials and do not provide erosion control benefits.[8]

In addition to providing a more secure and reliable fuelstock, cultivation of energy crops ensures greater consistency in the quality of the fuels. Plants in operation today were built for the primary purpose of burning waste, which can cover a wide range of forest and agricultural residues and waste materials from the wood and paper industries. Wood industry waste alone may consist of anything from sawmill wood chips to palletes and demolished building materials. The most common boiler designs today, pile burner and spread-stoker, require uniform particle sizes and consistent moisture content in order to maintain boiler heat rates and avoid maintenance problems.[9]

Fuelstock variety presents a problem from not only a quality perspective, but also in terms of handling. Fuelstock is usually prepared for combustion by screening for non-combustibles and sizing for uniformity. Sizing equipment geared for waste boards, such as saws, may be inappropriate for sizing bark or oversized chips. In addition, varying densities may mean that open storage piles present a moisture absorption problem for one fuelstock and not another, while conveyance systems designed for wood chips may get tangled in handling grape vines. In this regard, dedicated energy crops promise to facilitate handling operations by providing a consistent and reliable fuelstock.

Finally, the conversion of biomass heat to electricity is much less efficient than the conversion rate of coal to electricity. Where the heat content of coal ranges from 8,000 Btu per pound to 13,500 Btu, biomass ranges from 2,500 Btu to 4,000 Btu on a wet basis.[10] This variance is largely due to the high moisture content of biomass fuelstocks, which can reach 60% by weight, as opposed to the moisture content of coal at 10% or less. This is not necessarily a problem for existing biomass boilers. However, improved energy conversion rates offer to improve biomass economics and capabilities, thereby facilitating the development of new units.

FIGURE 2-25
TYPICAL BIOMASS ELECTRIC GENERATION SYSTEM



Source EIA/U.S. Export Council for Renewable Energy, 1993.

To this end, the industry is currently working on ways to improve direct combustion in conventional and fluidized bed boilers, in addition to pursuing the development of biomass gasification and liquefaction systems. A prominent example of this work is Whole Tree Energy (a technology trade name of the Energy Performance Systems corporation), which reduces the moisture content of a dedicated energy crop from 40% and 50% to 20% and 30% by drying whole sections of trees prior to combustion. Heat rates (i.e., the amount of heat required to generate one kilowatt hour) for Whole Tree Energy compare to older coal boilers at 10,500 Btu per kilowatt hour, versus traditional biomass technologies at 14,000 Btu per kilowatt hour (higher heat rates indicate lower boiler efficiencies and should not be confused with the heat content of fuels).[11]

MODULARITY

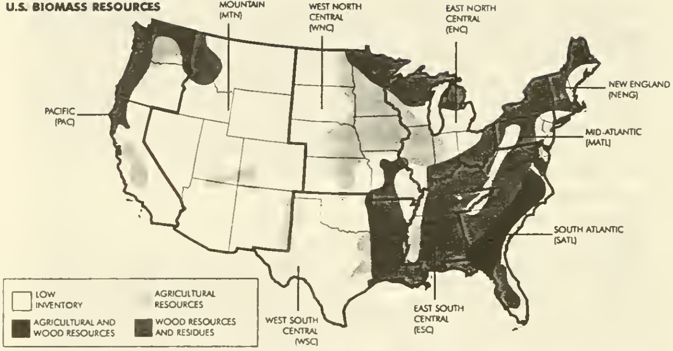
While biomass boilers are not modular in the same sense as wind turbines or geothermal units, their intermediate size does offer relief from the large, up-front capital expenditures found with typical baseload coal plants. By the same token, this intermediate size offers neither the true benefits of modularity nor the economies of scale found in larger plants. Further, the variety of crops and waste that might serve as a fuelstock prevent development of a uniform system design, which is an innate characteristic of modularity.

LOCATION

As with other renewable sources of energy, biomass generators must be located close to their energy resource. However, unlike wind, solar, or geothermal energy which are tied to a resource locale by pure physical constraints (i.e., these resources cannot be transported to a remote generator site), biomass energy has the physical potential to be transported, but is held back by economics. As a general rule, biomass generators must source their fuel from within a fifty mile radius.[12] With transportation as with boiler energy conversion efficiencies, high moisture content drives up the cost per unit of energy. In other words, a biomass project must pay for one ton of biomass fuelstock to be transported, but only generates revenue on 40% to 50% of that weight since the rest is noncombustible moisture.

Therefore, biomass energy is available in some parts of the country and not in others. Agricultural and forest residues are primarily available east of the Mississippi River and in the Pacific Northwest, small parts of the West, and California. The potential area for energy crops, SRWC and HEC, covers more of the East and extends further into the Midwest, but does not generally exist in the West outside of California and the Pacific Northwest. Within these regions, the potential for biomass resources, particularly for energy crops, depends on the availability of land given that a 100 megawatt biomass plant requires from 85,000 to 105,000 acres over its lifetime (assuming 40 dry tons per acre and a ten year SRWC growth cycle).[13] In fact, for biomass to generate 10% of total U.S. electricity requirements, 40 million acres (equal to 12% of total U.S. farmland or 134 cities the size of Los Angeles) would have to be cultivated with energy crops.[14]

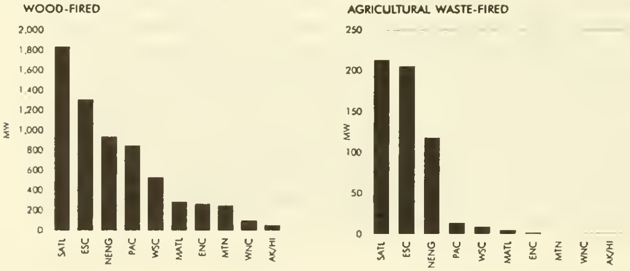
FIGURE 2-26
U.S. BIOMASS RESOURCES



SOURCE: NREL "PROFILES IN RENEWABLE ENERGY CASE STUDIES OF SUCCESSFUL UTILITY-SECTOR PROJECTS." GOLDEN, CO., 1994

In terms of location relative to the grid, biomass energy splits between plants burning residues and plants burning energy crops. Residue burning plants are tied to parent industries, such as lumber or paper, which are usually located near population centers and have grid access. Energy crop plants, on the other hand, may be located more remotely due to land requirements and transportation incentives to site as close to the resource as possible. In these cases, the cost of building transmission access is an added cost to the project which may or may not prevent development of lines. Variables affecting the project's success will include size of the plant and distance to the grid. For dedicated energy crop plants, the required combination of adequate land for crop cultivation, access to water for steam production, access to the grid, and availability of a permittable air shed will probably yield few appropriate project sites.

FIGURE 2-27
NON-UTILITY DEVELOPED CAPACITY BY REGION



Source: EIA, 1993

COSTS AND INCENTIVES

The economics of biomass electricity generation depend on several factors, including technology, location, and fuelstock. Of these, fuelstock tends to be the most important consideration because it drives both technology and location. Projects burning residue must be located at or near an existing industry, tend to be smaller in size due to the variability and limited nature of the fuelstock, and tend to employ more traditional boiler technologies. These projects also enjoy lower fuel costs on a per unit basis because the parent industry "subsidizes" production of the fuelstock.

Energy crop projects, however, must cultivate their own fuelstock and consequently have a much higher fuel cost. For example, a June 1994 study by Minnesota Power found a 300% difference in fuel prices between harvesting existing forest and cultivating a dedicated energy crop (i.e., trees). That difference in fuel cost drives energy crop projects to larger unit capacities in order to gain economies of scale. Greater stability of supply and consistency in fuel quality also help to offset the higher fuel costs.

Assuming a 50 megawatt fluidized bed combustor burning wood residue, RDI calculated levelized production costs ranging from 9.6¢ to 12.9¢ per kilowatt hour. Accelerated depreciation and a 1.5¢ per kilowatt hour federal subsidy have been included, otherwise the costs would be higher. Variances in these costs result primarily from alternate financing assumptions, although a full explanation of the methodology behind these calculations is available in Section IV and the Technical Appendix of this Study .

Obviously, not all potential biomass projects have been able to match current power market competition given that biomass capacity additions decreased from 614 megawatts in 1989 to about 275 megawatts in 1990.[15] Other factors depressing biomass development include U.S. Department of Agriculture crop support payments and payments to farmers not to cultivate some acreage, both of which tend to discourage investment in new types of crops.[16]

Finally, the ISO4 11th year is severely impacting the biomass industry in California. Economic failure of plants holding ISO4 agreements has reduced the state's biomass capacity from 850 megawatts in 1991 to 635 megawatts today and a projected 100 megawatts by 2000.[17] In response, the California Biomass Energy Alliance has proposed a five-year, 25¢ per month ratepayer surcharge to the CPUC and California state legislature. The funds collected would be kept in a pool and distributed to projects entering or beyond their 11th year, with each project collecting the difference between short run avoided costs (i.e., market price) and 6.5¢ per kilowatt hour (the level at which most projects believe that they can sustain economic viability).[18]

EXTERNAL COSTS AND BENEFITS

A strong argument made in favor of generating electricity with agricultural waste is that it controls the burning of residues, removing up to 98% of the emissions that would have occurred in an uncontrolled open burn, including emissions of CO_2, sulfur oxides, and mercury. Such is the case in California where one-third of all agricultural residues (consisting of prunings from 750,000 acres of almond trees, 125,000 acres of walnut trees, and 500,000 acres of citrus trees) that would have been burned in a pile are now burned in a combustor.[19] This serves the double purpose of generating electricity and controlling particulate emissions.

However, in an increasingly deregulated electric utility industry, the relatively high cost of burning agricultural waste may be transferred away from utility ratepayers to the industries generating the waste. In other words, since electricity will have to be competitive in the open market, the cost of reducing agricultural emissions will increasingly be borne by the agricultural industry and reflected in the costs of paper and wine, rather than electricity. To the extent that those who generate the agricultural waste find it economical to generate and sell electricity at market rates, they will be able to offset a portion of the costs of emissions compliance. However, ratepayers in California will not be subsidizing the price of agricultural products consumed outside their state, and their host utilities will find themselves in a more competitive position regionally.

Much greater environmental and economic concerns exist in the area of energy crop cultivation. To plant and harvest fuel for combustion requires agricultural practices employing petrochemicals, such as fertilizers and herbicides, and machinery run on internal combustion engines will negate the renewable and CO_2 absorption aspects of biomass to a degree. This effect is more pronounced in HEC cultivation than in SRWC cultivation.[20]

The greatest environmental concerns, however, stem from land requirements for energy crop cultivation and the specter of harvesting existing forests for fuel. The National Audubon Society has been cited as being concerned about land requirements that would consume 12% of the nation's farmland to generate little more than 10% of its electricity supply.[21] That group, and most other environmental groups, also strongly object to the harvesting of forests for fuel.

In its study of renewable energy sources, Minnesota Power found that a hypothetical Whole Tree Energy project in its territory would be required to harvest existing forest for five to seven years before trees planted as energy crops would reach maturity.[22] Other sources question the appropriateness of harvesting any trees at all, arguing that recreational, wildlife, scenic values, as well as soil stabilization and CO_2 absorption, make forests incompatible with harvesting.[23]

Ultimately, the lack of economic viability of energy crop cultivation coupled with environmental concerns and more valuable land use alterntaives lead to numerous obstacles for such an approach.

Conversely, it is likely that biomass waste applications will continue to grow, as long as public policy and environmental initiatives continue to take into account the emergence of a more competitive electric utility industry.

SUMMARY

Biomass generators represent the largest segment of renewable energy capacity in the United States today. The success of this energy source is due to proven technology and a "subsidized" fuel source, that is, biomass waste from industrial facilities. Because power plants burning this waste may face capability and availability derates (i.e., drop in ability to generate to plant capacity) due to inconsistency in fuel supply and fuel quality, developers have proposed the cultivation of dedicated energy crops. Benefits of such a scheme include enhanced capability and availability, as well as improved economics from scale and consistent fuel quality. Drawbacks include significantly higher fuel costs and, in the case of tree burners, the need to harvest existing forests until energy crop trees mature. Also, large scale capacity additions face unrealistic land requirements.

Environmental benefits of biomass include low sulfur content and a relatively clean combustion by-product. Newer biomass technologies offer an alternative to older industrial boilers and the uncontrolled open air combustion of agricultural forestry residues, which may emit organic substances and carcinogens. In addition, energy uses for biomass may promote better forestry management, and the cultivation of certain HEC species may prove beneficial in preventing soil erosion.

Overall, biomass energy is a mature technology relative to most other sources of renewable energy. In fact, it is the oldest source of man-made energy. Prospects for further development of this energy source depend on economics, including the cost for alternatives to waste disposal. At this time, the low cost of fossil fuel alternatives is more competitive than biomass. While technological advancements in combustion may improve biomass economics in the future, capacity constraints based on substantial land requirements will continue to prevent biomass from significantly displacing any of the country's traditional sources of energy.

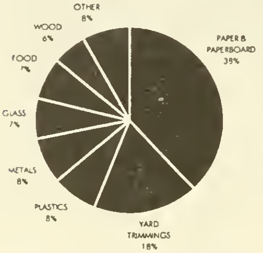
Municipal Solid Waste (MSW)

INTRODUCTION

The Environmental Protection Agency (EPA) defines municipal solid waste (MSW) as residential and non-process industrial wastes, excluding industrial process wastes, hazardous wastes, municipal sludge, and construction or demolition waste. The United States generates over 200 million tons of MSW every year, with 84% of that volume consisting of organic material and 16% consisting of inorganic material, such as glass and metals. Residential waste accounts for between 55% and 65% of annual volume. Just less than two-thirds of all MSW is disposed of in landfills, with approximately 20% recycled and more than 17% incinerated.[1]

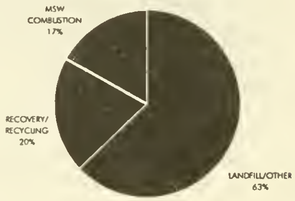
Recycling and incineration have both been growing as alternatives to landfills. In fact, incineration grew from 13% of all MSW volume generated in 1990 to 17% in 1992, with an increase in the number of MSW incinerator facilities growing from 114 to 123 over that same period.[2] Of all MSW incinerators, approximately 70% generate electricity, also called "waste-to-energy" (WTE). Driven more by the cost of landfilling than by the attractiveness of electricity markets, municipalities view WTE as a waste management alternative with electricity sales helping to defray costs. Therefore, the potential for WTE to serve as a renewable energy source depends as much on the cost of producing electricity from other energy sources as it does on the cost of recycling or landfilling.

FIGURE 2-28
MATERIALS GENERATED IN MSW, BY WEIGHT, 1990



Source U.S. EPA, Characterization of Municipal Solid Waste in the U.S. 1992 Update, EPA/530-R-92-019 Washington,DC, July, 1992, PES-4

FIGURE 2-29
MANAGEMENT OF MSW IN THE U.S., 1992



Source U.S. EPA, Characterization of Municipal Solid Waste in the U.S. 1992 Update, EPA/530-R-92-019 Washington,DC, July, 1992, PES-4

CAPABILITY AND AVAILABILITY

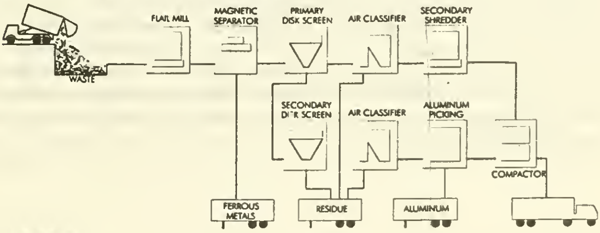
WTE electricity generation capacity was rated at 2,300 megawatts in 1992, with 11 million megawatt hours of generation recorded. Those figures were up from 1,810 megawatts and 8 million megawatt hours in 1990. As noted above, 67% of all incinerators generated electricity in 1992, up from 60% in 1990.[3] Clearly, the trend among incinerators has been toward greater utilization of MSW for electricity generation given the potential for energy revenues.

WTE electricity generators have dispatch capabilities that potentially span baseload and intermediate positions. While the major WTE projects are designed to run as continuously as possible, serving in a baseload or intermediate position, others may be driven more by their incineration schedule than by utility demand requirements. Overall capability may also depend on operating and maintenance issues unique to MSW as an energy resource, with handling difficulties and inconsistent fuel quality affecting availability.

The average unit size for all types of WTE generators is 34 megawatts, although this average represents both mass burn and modular technologies. Mass burn generators, which tend to be larger, have an average capacity rating of 50 megawatts. All WTE energy technologies experience relatively low energy conversion efficiencies at around 16,400 Btu per kilowatt hour generated.[4] This low efficiency is due to the low heat content of MSW as a fuel. Unprocessed MSW contains 4,500 to 5,000 Btu per pound,[5] although refuse derived fuels (RDF) (i.e., MSW separated and sized to remove non-organic materials) can reach 7,660 Btu per pound.[6] By comparison, the lowest rank marketable coals have over 8,000 Btu per pound and the highest rank have up to 13,500 Btu per pound.

There are currently 650 megawatts of WTE generation capacity dedicated to the combustion of RDF. A number of these burn "course" RDF, in which the MSW has been separated and shredded, while others burn "fluff," in which additional processing turns the course RDF into a fluffy material with low ash content.[7] Obviously, additional processing entails an additional cost, although this is set off to some degree by enhanced heat content of up to 7,660 Btu per pound.

FIGURE 2-30
TYPICAL REFUSE-DERIVED FUEL PREPARATION PROCESS



Source: EIA/EPRI, 1993.

Some parts of the MSW fuel stream may be high in plastics content. In those areas where plastic is concentrated, the heat content of MSW may run significantly above fuel stream average.[8] This fact highlights the inconsistency of MSW fuel quality. With unprocessed MSW especially, heat rates may vary considerably given pockets of plastic, metals, or glass in the fuel stream. The sizing of unprocessed MSW fuel is another concern affecting both handling and combustion characteristics. A disposed tire iron, if not sorted out prior to combustion, could become lodged in the chains conveying MSW into typical stoker boilers and cause down-time.

A side issue facing WTE generator capability is curiously related to recycling. As noted in the introduction, the proportion of MSW recycled is slightly more than the proportion incinerated. That recycling will deprive WTE generators of their fuel is hardly a concern at this time. Nevertheless, growing success in the recycling of certain materials may have a very material impact. For example, plastic contains up to 400% more heat content than MSW as a whole. If plastics were significantly removed through recycling, the average heat content for MSW would decline, along with WTE electricity generation economics. Although it would seem to follow that recycling of non-combustible materials, such as metals and glass, would benefit WTE generators, the truth is that these materials are already sorted from RDF's and are already a small proportion of all MSW.[9]

MODULARITY

WTE technologies are divided between mass burn designs and modular designs. Mass burn boilers consist of one burn chamber and are constructed on site, usually for larger projects, while modular boilers employ two stage combustion and are usually manufactured at a factory for smaller sites. The modular design provides advantages by way of lower up-front capital and flexibility in expanding the facility. The major disadvantage is in the redundancy of expensive environmental controls.[10] As a result, recent trends have clearly been toward mass burn designs over modular, with the number of mass burn projects growing from 60 in 1991 to 65 in 1992. The number of modular projects actually decreased over this same period, from 50 to 48.[11]

LOCATION

As discussed previously, MSW fuel contains low heat content, anywhere from 4,500 to 7,660 Btu per pound. As a result, transportation economics are unfavorable. Although RDF's on the upper end of the heat range can certainly travel farther than can unprocessed MSW, there is not much incentive to do so given the economic interplay of MSW disposal alternatives - - landfill, recycle, or incinerate. Therefore, WTE generators must locate at or near metropolitan centers. While this may have negative implications from an environmental standpoint, as will be addressed later, it does facilitate project economics by presenting access to the grid.

COSTS AND INCENTIVES

The interplay between MSW disposal alternatives and electricity generation alternatives has been emphasized throughout this section. Again, the driving force behind MSW incineration is the cost alternative of landfilling. Municipalities must pay a "tipping fee" to either a landfill operator or an incinerator operator to take away their garbage. Obviously, they will choose the least cost option. Nationally, 1990-1991 tipping fees at incinerators were $39 per ton of MSW and $35 per ton at state-of-the-art landfills.[12] Landfills in Wisconsin averaged $25 per ton in 1993, but varied from $20 to $50 per ton at new sites.[13] Larger landfills have lower tipping fees, but the same economies of scale may also apply to incinerators.

This study assumed a 40 megawatt mass burn WTE plant to calculate levelized production costs of 10.2¢ to 18.0¢ per kilowatt hour for new MSW/WTE power plant projects. Accelerated depreciation has been included. Variance in these costs result primarily from alternate financing assumptions, although a full explanation of the methodology behind these calculations is available in Section IV and the Technical Appendix.

Several factors from the MSW disposal side may influence the future economics of WTE. Public concern over landfills is pushing the EPA toward stiffer landfill operating regulations, thus increasing landfill operating costs.[14] Leachate management equipment and liners are already standard at state-of-the-art landfills and are extremely expensive.[15] On the other side, municipalities are beginning to see through the landfill shortage scare of the early 1990s and to realize that ample space is available. That realization should serve to pull back high landfill tipping fees that were based in part on the shortage scare.[16] Further, overall WTE economics may be pinched by the successful recycling of high Btu waste at some point in time, but government estimates do not predict a material effect anytime soon.

EXTERNAL COSTS AND BENEFITS

The environmental benefits of WTE stem from MSW disposal alternatives — landfilling and recycling. Of these, recycling appears to be the most environmentally benign approach. After that option, the question becomes whether to burn or bury garbage. Both present adverse consequences, burying through hazardous leachates and methane emissions, and incineration through various hazardous emissions, and leachates from disposal of combustion by-products.

State-of-the-art landfills have been fairly successful in managing their environmental effects by installing liners, leachate equipment, and methane collection systems. State-of-the-art WTE plants, however, emit SO_2, NO_x, hydrochloric acid (HCL), lead, cadmium, copper, arsenic, and mercury at rates which far exceed well-controlled coal plants, and also emit dioxin and furans, toxins not found at all in coal plant emissions.[17] Acid gas emissions from WTE, particularly HCL, are capable of materially damaging paint, metal, and stone.[18]

After incineration, the combustion by-products of MSW (i.e., ash) are generally placed in a landfill. This ash constitutes 30% of the original weight of the MSW prior to combustion and contains concentrations of heavy metals. When put in a landfill where mildly acidic conditions promote movement (i.e., leaching) of cadmium and lead, WTE ash qualifies under federal regulations (RCRA) as a hazardous material.[19] Consequently, one-third of the MSW combusted finds its way to a landfill anyway, albeit in a more hazardous form.

These emission and leachate hazards prompted Massachusetts and New Jersey to declare temporary bans on WTE (now lifted), while other states, Florida, Michigan, and Wisconsin, considered but did not enact bans.[20]

SUMMARY

WTE is a growing energy resource in the United States because of forces pushing it from MSW disposal markets, rather than forces pulling it to energy markets. Tipping fees for MSW disposal subsidize electricity production, while electricity revenues in turn reduce waste disposal costs. Industry trends are away from smaller landfills and incineration without electricity generation and toward larger landfills and larger WTE plants. Given that incinerators and recycling already account for almost 40% of all MSW disposed of annually, the potential for new WTE capacity is limited. Recycling will certainly continue to make gains, albeit at a slower pace than in the past, and landfills will increase competition with new capacity and lower tipping fees. It stands for new environmental control technology, not yet existing, to move WTE into the ranks of environmentally sound energy sources.

Municipal Solid Waste: Tires

INTRODUCTION

Tires represent a unique problem to landfills because they tend to rise and even pop through groundcover as other landfill materials compact around them. Many landfills do not accept large quantities of tires, if any, while others charge high tipping fees. Consequently, scrap tires are frequently placed in dedicated stockpiles. Anywhere from 107 to 240 million tires are scrapped each year, with 8% to 11% of that amount incinerated.[1]

CAPABILITY AND AVAILABILITY

Tires possess heat values of 12,000 to 16,000 Btu per pound, which makes them very suitable as a fuel.[2] They can be burned whole or shredded as a tire derived fuel (TDF). There are currently two commercial plants dedicated to generating electricity solely from tires, the Oxford Energy Plant in Modesto, California, and the Exeter Energy Company in Connecticut. Oxford is rated at 14 megawatts of capacity, consuming 4.9 million tires per year, while Exetern is rated at 30 megawatts of capacity and consumes 10 million tires per year.[3] Both source their fuel from dedicated tire stockpiles.

Tire boiler technology is similar to that of coal boilers. Therefore, tire plants have the same capabilities and availability as coal plants. The economics of the two existing plants are predicated on continuous operations. The availability of tires as a fuelstock, however, severely limits the overall capability of the technology to contribute significantly to the grid. Assuming that scrap tire volume is 170 million tires per year (average of the 107 million and 240 million tire estimates provided earlier) and that the two existing plants account for 15 million tires annually to sustain 44 megawatts of capacity, maximum electricity generation from annual scrap tire volume is 500 megawatts, not considering retread markets or existing stockpiles.

MODULARITY

The two plants in operation were built on-site near scrap tire stockpiles. The plants were designed to accommodate available fuel supplies, with little or no thought given to modularity.

LOCATION

The two plants in operation are sited near population centers with grid access. However, because of their high heat content, tires in the form of TDF can afford the economics of transportation. In fact, a few utilities with coal-fired plants sited remotely from scrap tire stockpiles, such as Ohio Edison, burn TDF in combination with coal.[4]

COSTS AND INCENTIVES

Utilizing a combustion technology similar to that for coal, tire plants can generate electricity competitively if their fuel costs are competitive. Tire plant developers currently estimate that the competitive price for fuel must be around $1.00 per million Btu.[5]

Electricity production costs include consideration for tipping fees from a stream of tires originating outside the existing stockpiles. Indeed, developers look for this stream as an added source of revenue, such that combustion of fresh scrap tires is more economical than combustion of tires from the existing stockpile. Other revenues are also available by diverting better conditioned tires into retread markets.

EXTERNAL COSTS AND BENEFITS

Tire combustion offers an alternative to scrap tire stockpiles, which are unsightly and serve as breeding ground to mosquitoes. However, tire combustion does produce atmospheric emissions. The sulfur content of tires is typically 1.23%, or about 1.8 pounds of sulfur dioxide per million Btu (given a heat content of 14,000 Btu per pound). This contrasts with Clean Air Act compliance limits for new utility power plants at 1.2 pounds per million Btu. Therefore, flue gas desulfurization may be required on new tire burning facilities. Other emissions of concern include zinc, cobalt, benzo(a)pyrene, benzene, and lead. Combustion by-products (i.e., ash) equal 5% of the weight of the tire fuelstock.[6] Rhode Island bans the burning of tires as a fuel source and prohibits their export from the state for fuel purposes.[7]

Another environmental issue pertaining to tires as a fuel ironically focuses on mosquitoes. While true that tire incinerators remove potential mosquito breeding grounds, they have also been suspected of causing the transport of mosquitoes. In one high profile example, tires shipped from Asia to serve as a fuelstock in the United States brought along the Asian Tiger mosquito, speculated to be responsible for the spread of encephalitis. The shredding of tires into a TDF prior to shipment is one solution to the problem, although this may entail additional costs.

SUMMARY

Like MSW in general, tire generated electricity is driven more by disposal alternatives than by electricity markets. Turning scrap tires into electricity is attractive because it provides an alternative to scrap tire stockpiles. Unlike typical MSW, tires have a high heat content and low ash content which makes them well-suited to combustion and electricity production. Concerns are evident in regard to atmospheric emissions, especially with regard to sulfur dioxide and benzene, although tires burn much more cleanly than typical MSW fuelstocks. The overall capability of tire generated electricity rests on economics and a realistic assessment of the role that this niche technology can play in meeting the demands of the grid.

Landfill Gas (LFG)

INTRODUCTION

In addition to the direct combustion of garbage, MSW can also serve as an alternative energy source in a gaseous form. Once a landfill becomes compacted and all aerobic bacteria (i.e., those requiring oxygen) disappear, anaerobic bacteria begin to proliferate. Over the course of anywhere from 10 to 100 years these bacteria produce quantities of methane and carbon dioxide (CO_2) gases, in addition to other trace elements, that must be vented and either flared-off or released into the atmosphere.[1] Recognizing a potential resource, a number of landfills now recover these landfill gases (LFG) for electricity generation or resale into gas markets. In 1991, fully two-thirds of all recovery projects generated electricity.[2]

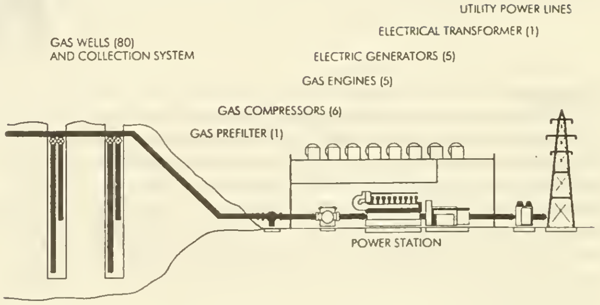
CAPABILITY AND AVAILABILITY

If all LFG in the United States were collected and processed, the total volume would equal 5% of total U.S. gas consumption or 1% of total U.S. energy demand.[3] By comparison, production of methane gas from coalbeds accounted for over 3% of total U.S. dry gas production in 1992.[4] As of 1992, LFG electricity generation capacity stood at only 377 megawatts, with individual plant capacity ranging from 0.07 megawatts to 47 megawatts, with the mean at 4.1 megawatts.[5] Total U.S. electricity generation from LFG in 1991 was only 2.9 billion kilowatt hours, or 2% of the total electricity generated in California that year.[6] Therefore, like tires, LFG is a niche player in the renewable energy field.

While comparable to natural gas turbines in terms of capability, LFG generators face diminishing returns over their 10 to 15 year life cycle, with peak gas production occurring in the early years.[7] Additionally, the availability of LFG generators is much lower than that of natural gas generators. One-third of LFG plants have reported an unplanned shutdown during their short existence. Causes include equipment problems, 64%; economics, 18%; retrofits, 15%; and lack of gas resource, 10%. The average shutdown lasted 51 weeks.[8]

LFG also differs from natural gas by virtue of its quality. Raw LFG holds 493 Btu/cubic foot versus 1,000 Btu/cubic foot for natural gas. LFG can be upgraded to 500 or 530 Btu/cubic foot by removing moisture with pretreatment scrubbers or dehydrating the gas with triethelene glycol. Condensers can further raise the quality to 700 Btu/cubic foot, and the removal of CO_2, hydrocarbons, and trace contaminants can upgrade LFG to natural gas pipeline quality.[9]

FIGURE 2-31
TYPICAL LFG ELECTRIC GENERATING SYSTEM



Source EIA/Pacific Energy

MODULARITY

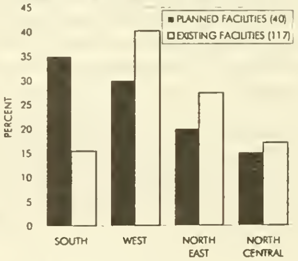
LFG electricity generators are designed to match their unique landfill resources. The technology is, therefore, not modular.

LOCATION

Because LFG electricity generators must be located at landfills generally larger than one million cubic yards in size, they are concentrated near large population centers.[10] California and New York are prime locations, as are Illinois, Pennsylvania, New Jersey, Michigan, and Wisconsin.[11] This proximity to population centers provides a similar proximity to grid access.

Although LFG quality can be upgraded to levels comparable with natural gas and fed into natural gas pipelines, the cost of upgrading provides less compelling economics than the cost of burning a lower quality fuel on site. Nevertheless, many projects do sell upgraded gas directly to industrial and residential end users.

FIGURE 2-32
LOCATION OF LFG PLANTS BY REGION, 1991



Source Governmental Advisory Associates, Inc., New York, NY - "Methane Recovery from Landfill Yearbook, 1991-1992."

COSTS AND INCENTIVES

As of 1991, 157 methane recovery projects were either operating (81% of the total number) or planned, which was only a 1.3% increase over the number of projects in 1988. Further, 13 existing projects shut down between 1988 and 1991 primarily for economic reasons and another 15 projects were scratched for the same cause. This slowdown in the LFG industry, which had seen 16 plants in 1982 grow to 138 by 1986 and 157 by 1991, corresponds with a depression in both fossil fuel prices and utility avoided costs.[12]

FIGURE 2-33
AGE OF METHANE RECOVERY FACILITIES

PLANNED START-UP DATE		
YEAR	#	%
1991	13	41.9%
1992	16	51.6%
1993	2	6.5%
TOTAL	**31**	**100%**

YEAR OPERATIONS BEGAN		
YEAR	#	%
1978	1	0.8%
1979	1	0.8%
1980	1	0.8%
1981	5	4.1%
1982	4	3.3%
1983	8	6.6%
1984	10	8.3%
1985	19	15.0%
1986	10	8.3%
1987	10	8.3%
1988	19	15.7%
1989	16	13.2%
1990	11	9.1%
1991	6	5.0%
TOTAL	**121**	**100%**

YEAR OPERATIONS TERMINATED		
YEAR	#	%
1986	2	22.2%
1987	2	22.2%
1990	4	44.4%
1991	1	11.1%
TOTAL	**9**	**100%**

Source: Governmental Advisory Associates, Inc., New York, NY - "Methane Recovery from Landfill Yearbook, 1991-1992."

Average LFG production costs of 4.58¢ per kilowatt hour for facilities under development in the early 1990s compare poorly to the average 6.18¢ per kilowatt hour prices held by existing facilities under power supply agreements signed in the 1980s.[13] In short, few LFG projects have been able to keep pace with falling energy prices.

Despite soft energy markets, the LFG industry remains optimistic as the result of new EPA landfill regulations that set forth standards for composite liners, leachate collection systems, groundwater monitoring, and methane collection. Over 6,000 landfills will spend an estimated $330 million to upgrade their facilities in order to comply with the new standards. LFG developers expect that these landfills will be attracted to new revenue streams, such as LFG electricity generation, to help defray their expenses. Further, the added costs of running a landfill may put many of the smaller facilities out of business and force larger, centralized landfills, which are more conducive to LFG development.[14]

The LFG industry has also been helped by EPAct, which includes the extension of an LFG tax credit. Originally provided under the Crude Oil Windfall Profits Tax Act of 1980, this tax credit was set to expire for all new LFG facilities entering service after December 31, 1992. The new deadline for qualification is December 31, 1996, with a termination date of January 1, 2008. The value of the credit is based on a barrel-of-oil equivalent, which was $5.35 in 1991 and adjusted for inflation to $5.53 in 1992. It applies to sales of LFG from a recovering facility to a buyer which has less than an 80% common ownership interest in the recovering facility, or less than a 50% ownership interest between a parent corporation and its subsidiary. Several companies now take advantage of the tax credit by partnering on projects, with one company recovering the gas and the other generating electricity.[15]

EXTERNAL COSTS AND BENEFITS

Despite the fact that methane is not a regulated emission, LFG advocates believe that the technology is attractive because it combusts gases that would otherwise be flared into the atmosphere. Given that organic and municipal waste is estimated to contribute from 3% to 10% of worldwide methane emissions (methane is a greenhouse gas), LFG and WTE offer a means of methane reduction.[16]

SUMMARY

LFG electricity generation is environmentally attractive because it combusts gases that would otherwise be flared. In the current energy market, however, LFG has not been able to compete, despite a federal tax credit. Even in a best case economic scenario, LFG supplies amount to less than 1% of total U.S. energy annual requirements, and regeneration of the resource requires anywhere from 10 to 100 years, which is significant relative to other sources of renewable energy. Finally, availability at existing facilities indicates that LFG is a less reliable source of energy than traditional resources.

Other Emerging Technologies

OCEAN ENERGY SYSTEMS

The Earth's oceans store enormous amounts of energy in the form of tidal and wave action, as well as in the form of salinity and thermal gradients. However, these resources are rarely concentrated, are dispersed over vast distances, and tend to be located far from regions of high electricity demand. While most ocean-energy systems remain in their infancy, tidal energy offers the best prospects for the near future and is, in many respects, a proven technology.

Tidal energy has long been exploited by humans. In AD 1100, tide mills were used to turn waterwheels along the western coast of Europe. All but forgotten for many years, a resurgence of interest and experimentation in tidal power has occurred, largely driven by energy security concerns and environmental benefits. Today, tidal energy systems consist of a dam equipped with multiple sluices surrounded by units of steel or concrete. Within these sluices, turbines are housed to generate power as water is pushed and pulled through them by tidal forces. Depending on generator type, electricity can be produced by water moving one way or in both directions.

Several operating methods are viable for tidal-energy systems. The simplest and most common is *ebb generation*, which lets water through the sluices during high tide, storing it until the tide goes down. As soon as there is enough distance between the head (i.e., the distance from the ocean to the height of the turbine within the sluice) and the low tide, the water is released and electricity generated. Variations on this theme attempt to harness the energy as it enters the basin as well, but usually do not result in a significant increase in overall production as technical difficulties for "dual capture" are presented.

As the gradient of head is increased more electricity can be produced. Pumping systems are also being pursued as a viable method to increase this potential, but require external energy sources to actively pump the water which results in only a 5% to 15% net energy gain. In order to increase efficiency and economic favorability, these dams must maximize tidal gradient and be located at limited sites that experience substantial shifts in water level over the tidal cycle.

There are currently over 250 megawatts of installed capacity around the world, although none are in the U.S. Only two project sites have been proposed in this country (Knik Arm and Turnagain Arm, both in Alaska) with theoretical capacities of 2,900 megawatts and 6,500 megawatts. The realization of these projects, however, is far from possible given prohibitive production costs of greater than 50¢ per kilowatt hour.[1]

Other ocean technologies, such as wave and ocean thermal energy conversion are even more cost prohibitive, with unproven technologies in the $10,000 per kilowatt hour range.[2] Future growth in this field will focus on lowering development costs, increasing technical viability, and garnering government support to continue R&D projects.

SOLAR HYDROGEN

One of the limiting characteristics of many renewable energy resources is their intermittent nature. However, if renewable energy sources were used to produce a fuel base that could be easily created, stored, and dispatched, new markets could open within traditional energy markets. Hydrogen is one such possible energy carrier and could be used as a new fuel source.

Hydrogen, like electricity, is a secondary energy source that must be produced by fossil, nuclear, or renewable energy resources. Widely available, hydrogen is derived through water electrolysis, where water is split into its constituent elements (i.e., hydrogen and oxygen gases) by an electrolyzer. This process is expensive, and its current capacity is limited to chemical refinement applications. Overall capital costs for a 10 megawatt hydrogen plant are in the $600 per kilowatt hour range.[3]

Advanced photoconversion methods that directly split water molecules are being pursued for transportation applications, though the targeted delivered price is likely to remain higher than traditional fuel sources.[4] Hydrogen fuel cells are being tested as an alternative fuel source for automobiles, although the high compression and volatility of this fuel type may limit storage capabilities. Utility applications, however, are not likely to become a viable economic possibility in the near future.

Section III
Coal Revisited

Introduction

In 1993, 454 coal-fired utility power plants, totaling 320,596 megawatts of installed capacity, generated 55% of all electricity produced in the United States by both utilities and non-utilities. Rather than decreasing in importance over time, coal-fired electricity has grown steadily in terms of both real generation and proportion of the total U.S. electricity supply. In fact, 7,300 megawatts of new coal-fired capacity are currently under construction or planned by electric utilities. This trend began as a response to the same oil crises of the 1970s that also gave birth to PURPA and incentive programs for renewable energy sources. Starting with 44% of U.S. generation in 1971, coal-fired utility power plant capacity has grown by 100%, supported by stable and low-cost coal prices.[1]

With new plant development stymied in the nuclear industry as the result of accidents at Three Mile Island and Chernobyl, and hydroelectric generation curtailed as the result of new environmental regulations limiting reservoir discharge, coal stands alone as the only current energy resource capable of meeting new baseload demand into the next century. Therefore, the growth and importance of coal generation promises to continue. Since the economic advantages of coal are virtually undisputed, perhaps it is useful to first revisit the environmental realities of coal.

TABLE 3-1
ANNOUNCED NEW COAL-FIRED UNITS

UTILITY	PLANT	STATE	SIZE (MW)
ADVANCED PLANNING OR UNDER CONSTRUCTION			
VIRGINIA POWER	CLOVER #1& #2	VA	782
SOUTH CAROLINA PUBLIC SERVICE	CROSS #1	VA	540
ORLANDO UTILITIES COMMISSION	STANTON #2	FL	433
SOUTH CAROLINA ELECTRIC & GAS	COPE	SC	365
WISCONSIN PUBLIC SERVICE	RHINELANDER	WI	122
TAMPA ELECTRIC	POLK IGCC	FL	110
BLACK HILLS POWER & LIGHT	SIMPSON #2	WY	80
SUBTOTAL			2,432
PLANNED			
TEXAS UTILITIES	TWIN OAK #1& #2	TX	1,500
VIRGINIA POWER	UNKNOWN PC	VA	800
PACIFICORP	UNKNOWN	TBD	700
SAN ANTONIO PUBLIC SERVICE	J.K. SPRUCE	TX	500
CINCINNATI GAS & ELECTRIC	UNKNOWN	OH	400
DELMARVA POWER & LIGHT	DORCHESTER	TBD	300
KANSAS CITY POWER & LIGHT	UNKNOWN	MO	250
EMPIRE DISTRICT ELECTRIC CO	UNKNOWN 2000	MO	160
SPRINGFIELD CITY UTILITIES	UNKNOWN	TBD	75
ST. JOSEPH LIGHT & POWER	UNKNOWN	MO	75
GOLDEN VALLEY ELECTRIC ASSOC.	HEALY	AK	53
MANITOWOC PUBLIC UTILITIES	#8	WI	40
SUBTOTAL			4,853
TOTAL			7,281

Source: EIA Form 714, NERC Form IE 411

External Costs and Benefits

EMISSIONS

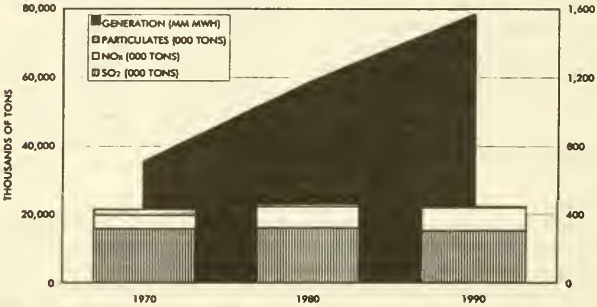
The public image of coal-fired power plants is often tied to footage from the 1950s showing black clouds billowing out of smokestacks. Yet, there is as much difference between coal plants of that era and coal plants today as there is between automobiles of the two eras. In 1995, for example, cars employ catalytic converters, burn unleaded gasoline, and are powered by a much more efficient engine that gets two or three times more mileage per gallon than the 1955 version. Most of these changes in automobiles were brought about by the same federal legislation that also brought about changes in power plants.

Foremost among that legislation is the Clean Air Act of 1970 and its amendments, the Clean Air Act Amendments of 1977 and 1990. The original Act set a standard sulfur dioxide (SO_2) emission limit for new power plants at a rate of 1.2 pounds per million Btu. Plants built between 1970 and 1977 can comply with this limit by either burning fuels with lower sulfur content, by "scrubbing" emissions with flue gas desulfurization (FGD) technology, or by building fluidized bed combustion plants, both atmospheric (AFBC) and pressurized (PFBC). Where FGD systems "scrub" emissions with lime or limestone after combustion to absorb SO_2, AFBC/PFBC plants inject lime directly into the boiler during combustion.

The 1977 Amendments strengthened the original Act by requiring that plants built after 1977 employ FGD and/or the best available technology. Weaknesses in this legislation stemmed from the fact that plants existing prior to 1970 (or even built later, but planned prior to 1970) were generally not affected and that a reduction in the *rate* of emissions at affected plants did not necessarily translate into a reduction of total emissions.

The Clean Air Act Amendments of 1990 (CAAA) addressed these issues by requiring that all existing plants, in addition to new plants, reduce their emissions of SO_2 and nitrogen oxide (NO_x). Unlike earlier legislation, the CAAA did not dictate compliance technology or emission rate limits. Instead, a 10 million ton reduction in SO_2 emissions from 1980 levels (a 62% drop from utility coal emissions of 16 million tons) and a 2 million ton reduction in NO_x emissions from 1980 levels (a 33% drop from utility coal emissions of 6 million tons) was targeted and each plant assigned an emission ceiling based on the number of Btu's burned on average from 1985 through 1987 multiplied by an allowable emission rate (2.5 pounds of SO_2 per million Btu during 1995-1999, called Phase I, and 1.2 pounds SO_2 per million Btu as of 2000, called Phase II).

FIGURE 3-1
UTILITY COAL-FIRED GENERATION AND EMISSION TRENDS, 1970-1990



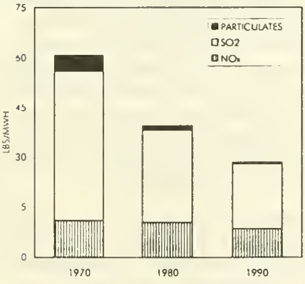
Source: EPA National Air Pollutant Emission Trends, 1900-1993
FERC Form 759, 1994

Therefore, each plant is assigned a fixed number of allowances for each ton of SO_2 and NO_x that it is permitted to emit. The method employed for reducing SO_2 emissions to the allowed ceiling is up to the discretion of each plant and may include switching to lower sulfur coal, retrofitting FGD, reducing generation, and purchasing excess allowances from plants in an overcompliance situation, among other options. Encompassing several of these options, the practice of "environmental dispatch" calls for moving cleaner plants to the head of the dispatch in order to capture as much low emission generation as possible and to hold back as much higher emission generation as possible.

The effect of the original Act and its first Amendment may be seen in the fact that, even though coal-fired generation has doubled since 1970, emissions of SO_2 per ton are down 48% and are continuing to decline. In fact, total U.S. SO_2 emissions are down 28% from 1971 and are at their lowest levels since the 1930s.[2] The difference in emissions between a 1992 vintage coal plant and a 1970 vintage coal plant is startling, given that FGD systems today remove up to 95% of SO_2 emissions. State-of-the-art plants, such as EPRI's SOAPP (state-of-the-art power plant) design are even more efficient and lower in emissions. Under the CAAA, a number of older vintage plants will retrofit FGD systems, while others will switch to lower-sulfur coal. Over time, however, all plants of older vintage will retire and will be replaced by the later, low emission, high efficiency designs depicted in Figure 3-3.

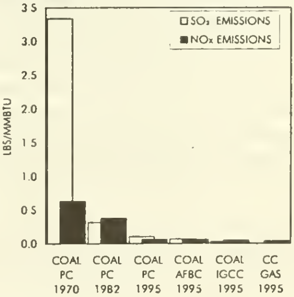
In the meantime, plants switching to lower-sulfur coal under the original Act and the CAAA have stimulated increased production of low-sulfur coal. As a result, the average sulfur content of coal burned in the U.S. dropped from 4.25 pounds of SO_2 per million Btu in 1972 to 2.26 pounds in 1994.[3] With Phase I of the CAAA commencing January 1, 1995, production of lower-sulfur coal is expected to continue to increase.[4]

FIGURE 3-2
AVERAGE EMISSIONS PER MEGAWATT HOUR FOR UTILITY COAL-FIRED GENERATION, 1970-1990



Source EPA National Air Pollutant Emission Trends, 1900-1993
FERC Form 759, 1994

FIGURE 3-3
COMPARISON OF EMISSIONS FROM VINTAGE COAL AND GAS TECHNOLOGIES



Source Pace, Stanley and Dale Sopocy, "Development of an Economical Advanced Pulverized Coal Utility Plant Commercial Design," 1994

COMBUSTION BY-PRODUCTS

Coal combustion by-products (i.e., ash) represent another area of coal-fired generation with potential environmental impacts. Typically constituting 10% of coal by weight (various supply regions will have higher or lower ash content), coal ash contains concentrations of trace elements such as arsenic, lead, chlorine, and mercury, albeit in amounts equal to tenths and hundredths of a percent of the levels set for hazardous materials under EPA's Toxicity Characteristic Leaching Procedure (TCLP) test. In fact, under the CAAA, Congress specifically exempted coal ash from categorization as a hazardous material, save for ash generated from AFBC/PFCB boilers.

Because AFBC/PFBC technologies inject lime directly into the coal boiler as a reagent to capture SO_2, the ash may become too alkaline to pass the TCLP test. This does not mean that AFBC/PFBC ash is necessarily difficult to dispose of or dangerous. On the contrary, the material has beneficial applications as fertilizer or neutralizers for acid run-off from coal mines. Likewise, ash from pulverized coal (PC) boilers, the standard coal plant design, has resale value as a building material, among other applications, and gypsum, the by-product from FGD systems, can be sold as a dry wall material or as fertilizer. Construction of the new Denver International Airport used 180,000 tons of PC ash.[5]

Resale markets have been able to handle approximately 20% of all coal ash generated by utilities each year.[6] As an alternative to resale, utilities place the ash in fills on the plant site in accordance with state environmental department regulations. An increasingly popular method of handling ash is to ship it back to coal mines. This method is employed by Public Service of New Mexico's San Juan station and Virginia Electric Company's Chesterfield Station, among many others.

DOE CLEAN COAL TECHNOLOGY PROGRAM

The Clean Coal Technology (CCT) Demonstration program, a shared government and industry program created in 1986, has created 45 projects at a cost of nearly $7 billion dollars (more than half of that amount funded by private companies).[7] The program was initially designed to demonstrate advanced coal-based technologies that minimize emissions of SO_2 and NO_x. Many of the programs are being examined as plausible utility compliance strat-egies with the CAAA. Recently, the CCT program has focused its attention on energy efficiency and reliability projects as many investor-owned utilities (IOU) and non-utility generator (NUG) executives are concerned about the possibility of future emissions regulations. The ultimate goal of the CCT program is to assist utility planners in choosing reliable, efficient, and environmentally sound energy solutions by providing a wide range of technological strategies that demonstrate these desired features.

A wide variety of CCTs have been successfully demonstrated. Among the most promising and economically realistic are advanced coal preparation techniques and conversion technologies, such as Integrated Coal Gasification Combined Cycle (IGCC) and coal liquefaction. TAMCO's Toms Creek IGCC, in Virginia, is an example of an IGCC CCT program

TABLE 3-2
CLEAN COAL TECHNOLOGY PROJECTS

STATE	CITY	COMPANY/PROJECT	TECHNOLOGY	COST (MILLIONS)	% FEDERAL
AK	HEALY	ALASKA INDUSTRIAL DEV AND EXPT. AUTHORITY	ADVANCED SLAGGING COMBUSTOR	215	48
CO	DENVER	ENERGY AND ENVIRONMENTAL RESEARCH CORP	GAS REBURNING AND LOW NOX BURNERS	16.2	50
CO	NUCLA	TRI STATE G&T	ATMOSPHERIC CIRCULATING FLUIDIZED-BED SYSTEM	54.1	37
CO	DENVER	PUBLIC SERVICE CO OF COLORADO	LOW-NOX BURNERS, NOX PORTS, SORBENT/UREA INJECTION	24.7	50
FL	LYNN HAVEN	SOUTHERN COMPANY SERVICES, INC.	LOW-NOX CONCENTRIC FIRING SYSTEM	9.2	49
FL	LAKELAND	TAMPA ELECTRIC CO	INTEGRATED GASIFICATION COMBINED CYCLE SYSTEM	242	50
FL	PENSACOLA	SOUTHERN COMPANY SERVICES, INC.	SELECTIVE CATALYTIC REDUCTION TECHNOLOGY	23.3	40
GA	NEWNAN	SOUTHERN COMPANY SERVICES, INC.	CHIYODA THOROUGHBRED-121 FLUE GAS CLEANUP	35.8	49
GA	COOSA	SOUTHERN COMPANY SERVICES, INC.	LOW-NOX WALL-FIRED BURNER W/ ADVANCED OVERFIRE AIR	14.7	45
IL	HENNEPIN/SPRINGFIELD	ENERGY AND ENVIRONMENTAL RESEARCH CORP	NATURAL GAS REBURNING AND SORBENT INJECTION	37.5	50
IL	SPRINGFIELD	ABB COMBUSTION ENGINEERING	INTEGRATED GASIFICATION COMBINED CYCLE	270.7	48
IN	CHESTERTON	PURE AIR ON THE LAKE, L.P	ADVANCED WET LIMESTONE FLUE GAS DESULFURIZATION	151.7	42
IN	RICHMOND	LIFAC-NORTH AMERICA	LIFAC SORBENT INJECTION PROCESS	21.4	50
IN	W TERRE HAUTE	DESTEC ENERGY, INC., AND PSI ENERGY, INC.	DESTEC ENTRAINED-FLOW GASIFICATION SYSTEM	396	50
IN	BURNS HARBOR	BETHLEHEM STEEL	GRANULATED COAL INJECTION	191.7	16
IA	PLEASANT HILL	DMEC-1 LIMITED PARTNERSHIP	PRESSURIZED CIRCULATING FLUIDIZED BED COMBUSTION	203	46
KY	CALVERT CITY	AIR PRODUCTS AND CHEMICALS, INC	2ND GENERATION PRESSURIZED FLUIDIZED BED COMBUSTION	375	40
KY	WEST PADUCAH	AIRPOL INC	GAS SUSPENSION ABSORPTION FOR FLUE GAS DESULFURIZATION	7.7	30
KY	PADUCAH	TENNESSEE VALLEY AUTHORITY	COAL REBURN TECHNOLOGY	7.3	48
ME	THOMASTON	PASSAMAQUODDY TECHNOLOGY, L.P	FLUE GAS RECOVERY SCRUBBER	16.5	36
MD	EASTON	EASTON UTILITIES	COAL-FIRED DIESEL ENGINE	37.3	50
MD	SPARROWS POINT	BETHLEHEM STEEL CORP	DAVY/STILL-OTTO PROCESS FOR CLEANING COKE OVEN GAS	45.2	30
MT	COLSTIP	ROSEBUD SYNCOAL PARTNERSHIP	ADVANCED CONVERSION OF LOW-RANK COALS	39	50
NV	RENO	SIERRA PACIFIC POWER CO	KRW FLUIDIZED BED GASIFICATION SYSTEM	270	50
NJ	CAMDEN	CAMDEN CLEAN ENERGY PARTNERS, L P	BRITISH GAS/LURGI GASIFICATION COMBINED CYCLE	780	25
NY	LANSING	NYSEG	S-H-U WET LIMESTONE SCRUBBER/UREA INJECTION	158.6	28
OH	CLEVELAND	CENTERIOR ENERGY CORP	COREX HOT IRON PROCESS WITH POWER GENERATION	825	18
OH	ABERDEEN	BABCOCK & WILCOX	LOW-NOX CELL BURNER SYSTEM	11.2	48
OH	LORAIN	BABCOCK & WILCOX	LIMESTONE INJECTION AND LOW NOX BURNERS	19.4	39
OH	NILES	MK FERGUSON CO	NOXSO REGENERABLE FLUE GAS CLEANUP PROCESS	66.2	50
OH	NILES	ABB COMBUSTION ENGINEERING	SNOX CATALYTIC ADVANCED FLUE GAS CLEANUP SYSTEM	31.4	50
OH	DILLES BOTTOM	BABCOCK & WILCOX	SOX-NOX-ROX BOX FLUE GAS CLEANUP PROCESS	13.3	46
OH	BRILLIANT	THE OHIO POWER CO	PRESSURIZED FLUIDIZED-BED COMBUSTION SYSTEM	193.5	31
PA	WILLIAMSPORT	COAL TECH CORP	SLAGGING COMBUSTOR WITH SORBENT INJECTION	1	50
PA	YORK	YORK COUNTY ENERGY PARTNERS, L P	CIRCULATING FLUIDIZED BED COMBUSTION SYSTEM	379.6	20
PA	SEWARD	BECHTEL CORP	IN-DUCT CONFINED ZONE DISPERSION FLUE GAS CLEANUP	10.4	50
PA	WARREN	PENNSYLVANIA ELECTRIC CO	EXTERNALLY FIRED COMBINED CYCLE PROCESS	146	50
TN	KINGSPORT	AIR PRODUCTS AND CHEMICALS, INC	LIQUID PHASE METHANOL SYNTHESIS (LPMEOH)	213.7	43
VA	COEBURN	TAMCO POWER PARTNERS	U-GAS GASIFICATION COMBINED CYCLE SYSTEM	196.6	48
WV	NEW HAVEN	APPALACHIAN POWER CO.	PRESSURIZED FLUIDIZED-BED COMBUSTION SYSTEM	917.9	20
WI	CASSVILLE	BABCOCK & WILCOX	COAL REBURNING FOR NOX CONTROL IN CYCLONE BOILERS	13.7	46
WY	GILLETTE	ENCOAL CORP	SGI INTERNATIONAL LIQUIDS-FROM-COAL (LFC) PROCESS	72.6	50
WY	GILLETTE	THERMOCHEM, INC.	MTCI'S PULSE COMBUSTOR/GASIFIER	37.3	50
MULT		ABB COMBUSTION ENGINEERING AND CO., INC	COAL QUALITY EXPERT SOFTWARE SYSTEM		
MULT		CUSTOM COALS INTERNATIONAL, INC	SELF SCRUBBING COAL ADVANCED COAL PREPARATION		

Source: U.S. Department of Energy, January 1994 currently under the planning and development stages. With a capital investment of $242 million, Toms Creek should effectively remove 99% of all sulfur emissions, gain a 20% increase in efficiency rating, and reduce net CO_2 emissions.[8] IGCC technologies are increasingly being looked to as an excellent repowering/retrofitting option. Liquefaction technologies utilize both indirect and direct methods to convert coal into a liquid. Put simply, coal liquefaction involves adding hydrogen to a liquefied form of coal which increases the heat content of the fuel. In the liquid form, sulfur and ash can be cleaned out before the combustion process and thermal efficiencies can be elevated.

As utility planners strive to reduce capital investments in the face of a deregulated market, future capacity additions will increasingly rely on cost-reduction strategies and a reliance on proven, risk reducing investments. Factors that will likely increase CCT marketplace potential will be in technologies that expand upon the asset profile of existing facilities. Retrofitting and repowering solutions, low-cost coal-prep methodologies, and conversion technologies (such as IGCC) are likely to be examined as a viable near-term solution. Continued demonstration of more advanced technologies will increase the available pool of choices of CCTs.

Capability and Availability

Coal technology is ideally suited to a baseload dispatch position for several reasons, including scale, availability of fuel supply, initial capital commitment, operational availability, and combustion characteristics.

First, coal-fired power plants range in size from just a few megawatts to 3,340 megawatts, with utility plants averaging 706 megawatts of capacity. Such scale is possible due to the successive design advances made in coal-fired boilers since the 1800s (evidencing a proven and familiar technology) and to the fact that coal resources are abundant and readily available. As one of the oldest industries in the U.S., the coal industry and its distribution infrastructures are fully developed, offering predictability of supply based on decades of experience.

Given this large scale, coal-fired power plant owners are greatly motivated to operate their plants continuously in order to amortize the capital required for initial construction. Fortunately for them, coal-fired boilers enjoy a high level of availability, with down-time arising mainly from routine maintenance. U.S. coal plant capacity factors averaged 53% in 1993, with the top fifty ranging from 74% to 98%. Plants experiencing lower capacity factors usually do so for economic rather than technical reasons. Overpriced coal supply agreements, available hydro power (usually in Springtime), and excess nuclear capacity are all examples of situations that may cause a utility to curtail generation at coal plants.

Finally, coal is ideally suited to a baseload position because of its combustion characteristics. Unlike oil and natural gas units, which can increase generation quickly (like stepping on a gas pedal), coal units require hours to ramp generation up or down. Other factors, ranging from fuel injection systems to optimum heat rate efficiencies, also lend themselves to continuous operation. Therefore, coal technology is perceived as unsuitable for peaking demand, with most coal plants serving baseload and a number serving in intermediate positions (notwithstanding a coal-diesel combined cycle project under development in Easton, Maryland, which is intended for peaking applications).

Modularity

Coal plants are generally not modular given the scale of their capacity and the substantial initial investment required. Certainly, coal plants are not modular at all in the same sense as wind turbines or photovoltaic panels. Nevertheless, multiple coal units can be built at the same plant site over time in order to take advantage of both economies of scale from shared systems (i.e., fuel handling, FGD, and smokestack) and certain modular characteristics (i.e., generating revenues at the first unit built while others remain in construction).

Basin Electric Power Coop enjoyed these dual benefits when it built three 570 megawatt units in the early 1980s, commissioning each unit in successive years. Black Hills Power & Light, on the other hand, has been using the Simpson/Wyodak plant site in Gillette, Wyoming since 1928 and recently added an 80 megawatt unit to complement existing 20 megawatt and 330 megawatt units. Other examples include Ohio Edison's Sammis plant on the Ohio River in Ohio, which consists of seven units built between 1959 and 1971.

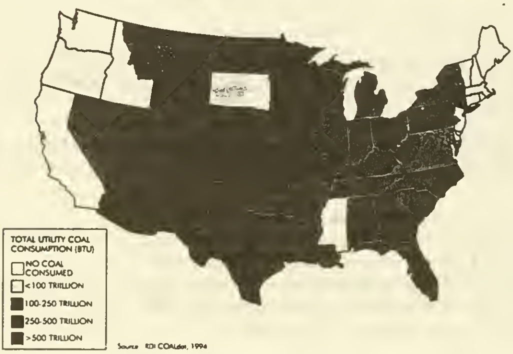
Coal technology is also enjoying modular benefits through use of an increasing number of factory built components. Where plants were once built almost entirely on site, major systems, including the boiler itself, are now delivered intact and ready for integration. Modularity in this sense contributes to greater availability by providing well proven system components, rather than one-of-a-kind designs.

Location

U.S. coal reserves are among the largest in the world, with sixteen major reserve basins located throughout the country. Given this abundance, coal is burned in every state, with at least one utility or non-utility owned coal-fired power plant located in forty-seven of the fifty states, including Alaska and Hawaii. Coal-generated electricity is most concentrated near the major coal basins in the Northeast, Midwest, Southeast, and West.

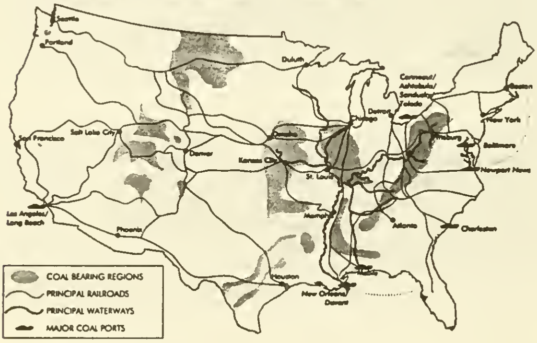
Because of its high heat content, coal can economically travel great distances across a distribution infrastructure consisting of railroads, highways, rivers, and coastal waterway routes. Coal from the Southern Powder River Basin in Wyoming, for example, frequently travels in excess of 1,700 miles and has been delivered to utility plants in Massachusetts and Florida via rail and barge. In such cases, transportation costs amount to as much as 70% of the total delivered cost of the coal. More typically, transportation represents about one-third of the cost with movements of a few hundred miles.

FIGURE 3-4
TOTAL UTILITY COAL BURN IN BTU, 1993



Source RDI COALdat, 1994

FIGURE 3-5
U.S. COAL BASINS AND MAJOR DISTRIBUTION CORRIDORS



Source RDI COALdat, 1995

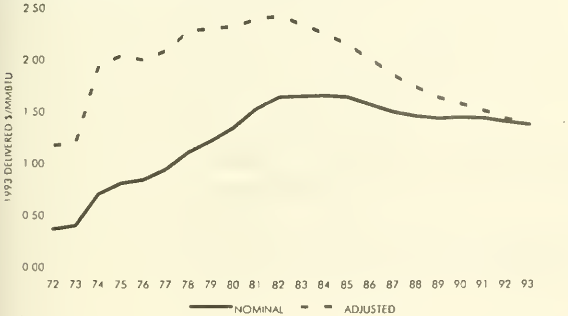
About 60% of all utility coal deliveries take place on railroads, 20% on barges or vessels, and 15% on trucks. The remaining 5% is delivered by conveyor belt to plants located at the mouth of the mine.[9] With transportation costs representing such a high proportion of delivered coal prices, especially for lower Btu Wyoming coal (8,800 Btu per pound versus greater than 12,000 Btu for Appalachian and Colorado coals), a host of mine-mouth coal plants were built in the 1970s and 1980s.

Usually located in remote areas, the large scale of these projects has justified construction of thousands of miles of transmission lines to deliver the electricity to high demand regions. Examples include Montana Power's 2,300 megawatt Colstrip plant near Billings, Montana, the Salt River Project's 2,700 megawatt Navajo Generating Station near Page, Arizona, and Basin Electric Power Coop's 1,700 megawatt Laramie River Station in Wheatland, Wyoming. Electricity from these stations flows to Washington and Oregon from Colstrip, to California from Navajo, and to the Great Plains from Laramie River.

Costs

Prices for coal and coal generating technology have steadily declined since the mid-1980s. At that time, the same national energy policies and economics that drove utilities to emphasize domestic coal resources also drove major oil companies to invest in coal properties. This surge in demand nudged coal prices up until the mid-1980s when increasing production and oversupply pulled coal prices back. In nominal terms, the delivered price of coal slid from $1.65 per million Btu in 1985 to $1.36 per million Btu in 1994 (close to a 50% decline when adjusted for inflation) and is still declining.[10] Likewise, the cost of coal com-

FIGURE 3-6
HISTORIC COAL PRICES: NOMINAL VS. INFLATION-ADJUSTED
(INFLATION-ADJUSTED 1993=100)



SOURCE RDI COALdat 1995

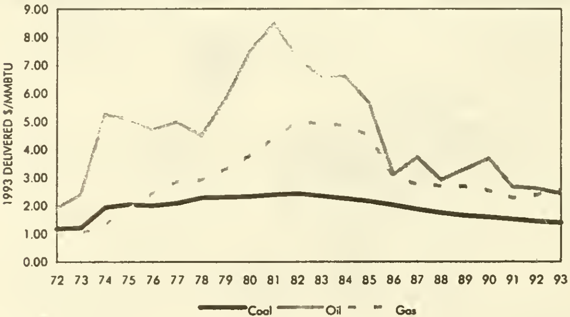
bustion technology dropped from well over $1,500 per kilowatt in the 1980s to $1,000 per kilowatt or less today (based on a 400 megawatt plant in the southeastern U.S., burning eastern bituminous coal, and assuming overnight construction).[11] In combination, lower coal prices and lower capital costs translate to levelized costs for new state-of-the-art coal-fired electricity production of about 4¢ per kilowatt hour in 1995 (see Section IV of this study).

Risk Diversity

The fact that coal-fired generation doubled over the past twenty years is, in part, testimony to the nation's interest in energy diversity. Although coal represents 55% of the country's electricity generation, it represents only 22% of total U.S. energy consumption. Oil, on the other hand, represents 39% of total U.S. energy consumption and would be even higher without coal. Furthermore, while the U.S. imported 49% of its oil requirements in 1993, the country was a net exporter of coal.[12]

Beyond balance-of-trade issues, coal serves the national interest relative to oil and natural gas by providing price stability. The benefits of such stability are obvious to those who experienced the two oil crises of the 1970s. In the last decade, nominal oil prices ranged from $4.35 per million Btu in 1980 to $5.43 per million Btu in 1981, $4.86 in 1984, and $2.44 in 1988. While natural gas tracked oil's volatility, coal prices hovered around $1.55 to $1.65 per million Btu from 1982 to 1986 before steadily declining to $1.47 per million Btu in 1988, $1.41 in 1992 and $1.36 in 1994.[13]

FIGURE 3-9
OIL, GAS, & COAL PRICES PAID BY ELECTRIC UTILITIES, 1972-1993
DELIVERED $/MMBTU (ADJUSTED FOR INFLATION 1993=100)



Source: RDI POWERdat, 1995

The U.S. possesses one-third of the world's coal resources, enough to last for another 250 years, and more energy than contained in the world's oil or natural gas reserves.[14] Given that coal plants are designed for a life of about thirty years, the U.S. has enough coal reserves to serve seven more successive generations of coal plants.

Summary

Over the past twenty years, coal combustion technologies have made tremendous strides in mitigating their environmental impacts. Today, all U.S. coal-mining and coal-fired generation facilities meet or exceed regulatory standards with a margin of safety for public health. A 1970 vintage PC boiler barely resembles the state-of-the-art PC designs available today. Emissions of SO_2 and NO_x from new plants are a fraction of the output from old plants, and this has paid off in an overall decline in U.S. emissions despite a doubling of coal-fired generation.

An abundant domestic fuel reserve capable of sustaining an additional 250 years of generation and a proven coal production and distribution infrastructure contribute to the technology's robust generating capability. Economically, coal technologies continue to outcompete all other fuels on a variable cost basis, except for hydroelectric and nuclear (both of which face capacity decline), and costs are continuing to decline. With no growth anticipated over the next ten years in either hydroelectric or nuclear generation, coal stands as the primary energy resource capable of meeting America's growing baseload electricity demand into the twenty-first century.

Section IV
America's Electric Generation Mix

Considerations in Determining the Future Electric Generation Mix

Each year, RDI develops a forecast of anticipated growth in electricity demand for the U.S. This forecast is based upon certain assumptions concerning regional population growth, energy prices, economic growth, electricity supply and demand balance, energy efficiency and electric intensity — that is, the relationship between economic growth and the demand for electricity. Once the electric demand forecast has been established, two key sets of considerations come into play to determine how U.S. electric utilities will meet anticipated growth in the demand for electricity.

First, it is necessary to analyze the ability of existing resources to meet growing demand through increased capacity utilization. This involves not just an understanding of overall capacity utilization, but also an analysis of availability by dispatch position. In other words, it is reasonable to assume that underutilized baseload plants, such as coal plants, will experience increased capacity utilization before new baseload capacity is added. Intermediate and peaking units typically do not increase their average capacity utilization rates because of their higher operating costs and because the capacity must be reserved for periods of peak demand.

Second, it is necessary to anticipate the capacity additions that will accommodate growth beyond installed generating capacity This is accomplished by evaluating every utility's load and resource plan, as well as capacity addition plans, filed with the various electric reliability councils. While these resource plans include new generating units in various stages of construction and planning, further determinations must also be made about long-term technology choices based upon the *levelized cost* of new generation alternatives.

RDI's forecast assumes that virtually no new major hydroelectric projects will be built in the U.S. during the forecast period for a variety of environmental and legislative reasons. For example, the EPAct specifically constrains re-licensing of hydroelectric projects, and in many cases current environmental mandates are causing reductions in existing capacity. Further, RDI assumes that no new nuclear projects will be brought on line in the foreseeable future and that existing capacity will begin to subside by the 2005 to 2010 time period, as current operating licenses expire and as nuclear waste disposal problems mount. In the meantime, all nuclear units able to increase their capacity factors will do so in order to optimize their remaining lives. And finally, RDI projects that very little, if any, new oil-based generation will be added during the forecast period due to environmental and market limitations.

This leaves three classes of technology to be considered in the future: coal, natural gas and renewables. Together, these three generating technologies must not only meet growth in electricity demand, but must also make up for the almost certain losses in hydro, nuclear, and oil generation.

Levelized Cost Methodology Overview

RDI calculated the levelized cost of new generation for various electric generation alternatives. Levelized costs consist of three key factors: 1) the capital cost associated with building the plant, plus ongoing non-fuel operating and maintenance costs; 2) the projected cost of fuel; and 3) the capacity utilization rate. A detailed discussion of the methodology and calculations behind RDI's levelized cost estimates are included in the Technical Appendix of this study, although a brief overview of the key factors follows.

CAPITAL AND NON-FUEL OPERATING COSTS

In order to determine the capital cost and other key operating parameters of each generating technology, RDI relied on the Electric Power Research Institute's 1993 Technical Assessment Guide (EPRI TAG), as well as vendor interviews and the most current data available from engineering and construction firms. In all, more than 120 technologies and technology variations were assessed and entered into a sensitivity analysis model that examines each technology under a variety of economic and utilization scenarios.

FUEL PRICES

For the cost of coal and natural gas, RDI relied on its most recent regional fuel price forecasts as published in its 1995 *Outlook for Coal and Competing Fuels.* The projected delivered prices of coal and natural gas used for each region of the country are presented in the Technical Appendix. It should be noted that the natural gas price forecast used here is more conservative (i.e., lower) than the most recent forecast set forth by the Gas Research Institute (GRI), resulting in relatively low levelized costs for natural gas.

Fuel prices for biomass and municipal solid waste (MSW) were obtained from various publications and reports, particularly from Minnesota Power's June 1994 study of renewables and a similar study conducted by the Wisconsin Public Service Commission. RDI conducted a sensitivity analysis to account for the wide variations possible in the cost of these fuels, as presented in the Technical Appendix.

The other renewable energy resources, wind, solar, and geothermal, are assumed to have no fuel costs. Although most geothermal projects do pay a resource royalty to the federal government or to a state government, this cost proved to be insignificant and was not factored into the levelized cost analysis.

CAPACITY FACTORS

The levelized cost of electricity production is also dependent upon capacity utilization (also called "capacity factor") assumptions, which represent the percent of total potential generation achieved by a plant in a given year. In order to determine reasonable capacity factors to apply to new generation technologies, RDI examined the newest and most efficient technologies available today.

> **COAL:** In the case of coal, it is not unusual to see modern baseload coal plants operating in the 80% to 90% capacity factor range. Typically, such plants enjoy relatively low, stable fuel costs and employ the most modern pollution control devices. For the purpose of this analysis, it is assumed that new, state-of-the-art, baseload pulverized coal (PC) plants will operate at an 80% capacity factor. Atmospheric Fluidized Bed Combustion (AFBC) coal technology, the other coal-based technology evaluated in this study, is assumed to operate at a 70% capacity factor. AFBC is less common than PC, but is important due to its extremely positive environmental characteristics and ability to burn a wide variety of coals and solid fuels.
>
> **NATURAL GAS:** Combined cycle natural gas units have been a part of several utilities' resource base since the mid-1970s. These older units typically are utilized for intermediate positions, and in some cases peaking positions, when the turbines alone are incrementally dispatched. However, since the late 1980s, a new generation of natural gas combined cycle units has been installed for annual and seasonal baseload applications by a few utilities attracted to the relatively low capital costs for small incremental additions. For the same reason, these units have been attractive to non-utility generators.
>
> RDI's research shows that these units can run at annual capacity factors of as high as 65% to 75% in areas such as Florida and Texas, where natural gas prices are relatively low. In other states where delivered natural gas is relatively competitive with coal only on a seasonal basis, such as Virginia and New York, these units dispatch at only 45% to 55% annually. In this study, RDI assumes that new natural gas combined cycle units will be dispatched on average at 65% annually. If anything, this assumption becomes aggressive by the end of the forecast period given expectations that the gap between natural gas and coal prices will grow over time. As the gap widens, natural gas will be dispatched less.

RENEWABLES: Capacity factor assumptions for the various renewable technologies are based upon actual experience, where available, and are otherwise obtained from the EPRI TAG or from industry associations.

Levelized Cost Comparisons

Taking into account the three key factors discussed above — capital and non-fuel operating costs, fuel prices, and capacity factors — RDI calculated levelized costs for new technologies based on coal, natural gas, and renewable resources. The following figure is derived from a base case discount rate (i.e., the time value of money) assumption of 6%, which is recommended by the EPRI TAG. Sensitivities for other discount rates, taxation under a public entity scenario, and interest during construction were explored with the results presented in the Technical Appendix.

TABLE 4-1
LEVELIZED COSTS

	BASE CASE								
	PULVERIZED COAL	AFBC COAL	GAS CC	WIND CLASS 4	BIOMASS	WASTE	GEOTHERMAL	SOLAR PV	SOLAR THERMAL
(IN 1993 DOLLARS)									
CAPITAL COSTS									
TOTAL PLANT COST ($/KW)	956	1,052	572	1,195	2,060	4,379	2,400	3,741	3,147
CONSTRUCTION PERIOD (YEARS)									
FUEL PRICES									
AVERAGE DELIVERED FUEL PRICE ($/MMBTU)	1.16	1.16	2.61	0.00	2.48	-3.50	0.00	0.00	0.00
O&M COSTS									
VARIABLE O&M (¢/KWH)	0.23	0.34	0.04	0.56	0.91	1.43	3.50	0.00	0.00
FIXED O&M ($/KW-YR)	43.48	33.97	27.08	0.00	95.12	136.91	28.47	5.99	65.44
LEVELIZED COSTS									
LEVELIZED FIXED CHARGE ($/KW-YR)	123.53	146.89	79.89	159.09	286.22	712.76	333.51	498.17	418.98
LEVELIZED O&M COSTS ($/KW-YR)	57.48	54.65	29.40	16.17	146.90	218.36	227.76	5.99	65.44
LEVELIZED FUEL COSTS ($/KW-YR)	76.90	73.12	133.52	0.00	292.12	(362.04)	0.00	0.00	0.00
CAPACITY FACTOR	80%	70%	65%	29%	70%	70%	90%	21%	26%
LEVELIZED COST OF ENERGY (¢/KWH)	3.8	4.6	4.3	6.8	11.8	9.3	9.2	27.4	21.0

Table 4-1 depicts the economics of various energy choices studied. Pulverized coal (PC) exhibits the lowest levelized cost (3.8¢ kilowatt hour) under the base case scenario, while solar Pv ranks the highest (27.4¢/kilowatt hour). The renewable alternative with the lowest levelized cost is wind, which is 79% higher than PC. The greatest sensitivities, however, are rooted in location. Specifically, RDI's analysis found that the relative economics of new technology additions are somewhat different from region to region given variations in both delivered fuel costs and the availability of renewable resources. The following table demonstrates the regional variations in RDI's levelized cost estimates, assuming the base case discount rate. This figure shows that new state-of-the-art pulverized coal (PC) technology is the least cost generating option in every region of the country, followed by AFBC coal and natural gas combined cycle, then by the various renewable technologies, which are much more regionally dependent due to resource availability issues.

TABLE 4-2
REGIONAL LEVELIZED COSTS IN ¢/KILOWATT HOUR
BASE CASE SCENARIO

	SOUTH ATLANTIC	EAST NORTH CENTRAL	EAST SOUTH CENTRAL	MIDDLE ATLANTIC	MOUNTAIN	NEW ENGLAND	PACIFIC	WEST NORTH CENTRAL	WEST SOUTH CENTRAL	BASE CASE
PULVERIZED BITUMINOUS COAL	3.9	-	-	4.1	-	4.2	-	-	-	4.1
PULVERIZED SUBBITUMINOUS COAL	-	3.8	3.6	-	3.5	-	4.0	3.5	4.0	3.7
ATMOSPHERIC FLUIDIZED-BED COMBUSTION - CIRCULATING	4.6	4.5	4.3	5.0	4.2	5.1	4.7	4.2	4.7	4.6
NATURAL GAS COMBUSTION TURBINE/COMBINED CYCLE	5.0	4.3	4.4	4.3	4.0	4.5	4.1	4.0	4.0	4.3
WIND - VARIABLE SPEED TURBINE - WIND CLASS 4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
WIND - VARIABLE SPEED TURBINE - WIND CLASS 5	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
WOOD-FIRED FLUIDIZED BED COMBUSTION - RESIDUE	8.3	8.7	8.5	9.3	9.0	9.3	9.0	8.7	8.5	8.8
WOOD-FIRED FLUIDIZED BED COMBUSTION - ENERGY CROP	11.5	11.8	11.7	12.5	12.2	12.5	12.2	11.8	11.7	11.8
MUNICIPAL SOLID WASTE - MASS BURNING	8.5	9.3	9.0	10.6	10.0	10.6	10.0	9.3	9.0	9.3
GEOTHERMAL - DOUBLE FLASH	-	-	-	-	9.2	-	9.2	-	-	9.2
GEOTHERMAL - BINARY	-	-	-	-	8.0	-	8.0	-	-	8.0
PHOTOVOLTAIC CENTRAL STATION FLAT PLATE	28.7	31.6	32.8	42.4	19.6	38.4	24.5	24.1	23.5	27.4
SOLAR THERMAL - PARABOLIC TROUGH	-	-	-	-	22.6	-	21.9	-	20.2	21.0

Generation Forecast Scenarios

While renewable technologies are not economically competitive with modern coal and natural gas technologies, they will still play a role in the nation's future generation mix.

RDI developed three generation mix scenarios to demonstrate the potential position and costs of renewables in the future. The first scenario, the Base Case, is RDI's best estimate of the future generation mix assuming that current renewables subsidies remain in place. The second scenario, Full and Open Competition, assumes that only economic considerations will be taken into account in the construction of new generation resources. And the third scenario, Subsidy Intensification, assumes that sufficient renewables subsidies will be imposed to overcome the economic advantages of coal and natural gas and that technical and geographical constraints become the primary limitation on the growth of renewables generation.

All three scenarios share basic assumptions concerning demand growth and the future availability of nuclear and hydroelectric capacity. Aggressive assumptions concerning energy conservation and energy efficiency result in a relatively conservative projection of growth in electric demand — averaging less than 1.5% per year over the forecast period. Nuclear and hydroelectric capacity varies with assumptions for capacity curtailments from nuclear retirements and from new reservoir and stream flow management regulations.

SCENARIO 1 - BASE CASE

The Base Case forecast assumes that existing renewables subsidies and tax incentives mandated at both the state and federal level will be maintained and that prices for coal, natural gas, and fuel oil continue to be subject to the open market.

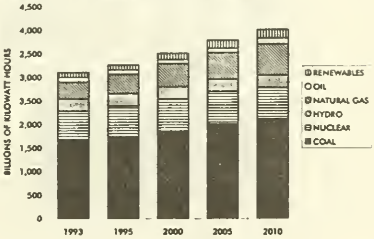
The Base Case contains the following assumptions for renewables. Waste combustion technologies including biomass, waste-to-energy, and landfill gas will grow at an annual rate of 5% (an aggressive assumption), driven by waste management costs in the agricultural, lumber, and landfill industries rather than by the economics of electricity production. That is, to the extent that environmental concerns and regulations require the control of agricultural and urban waste, it is assumed that these costs will not be subsidized beyond current levels. The production and sale of electricity at market rates will serve as a means of offsetting a part of each industry's environmental control costs, but will not drive the market price of power. In California, it is assumed that biomass capacity will actually contract from 635 megawatts today to 100 megawatts by 2000, the result of projects failing in the "11th year" of California's ISO4 power supply agreements.

Non-combustion technologies are projected to more than quadruple between 1995 and 2010 under the Base Case scenario. RDI assumes that expansion figures provided by the geothermal and wind power industries will be realized[1] and makes the aggressive assumption that Enron's proposed 100 megawatt solar Pv project in Nevada will be realized, although solar projects in general show very limited growth.

Under the Base Case scenario, RDI projects that renewable energy technologies may grow from about 2% of the national electricity mix today (including both utility and non-utility generation) to just under 3% by 2000 and about 4% by 2010.

RDI estimated the cumulative cost of this expansion by calculating the difference between the levelized costs of the projected renewables mix and the most cost effective technologies available today. Between 1995 and 2010, the cumulative cost will be $52 billion (1995$), not accounting for the subsidies already provided by the EPAct and by IRS rules for accelerated depreciation.

FIGURE 4-1
RDI BASE CASE GENERATION MIX FORECAST



	GENERATION (BILLION KWH)				
	1993	1995	2000	2005	2010
COAL	1,674	1,730	1,862	2,017	2,126
NUCLEAR	610	659	678	679	661
HYDRO	265	272	266	268	268
NATURAL GAS	353	410	484	564	656
OIL	97	83	86	88	122
RENEWABLE:					
COMBUSTION	53	54	67	87	92
NATURALLY OCCURRING	20	21	30	51	88
TOTAL	3,072	3,229	3,472	3,754	4,011

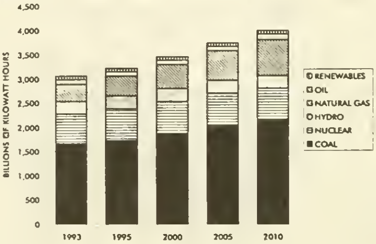
SCENARIO 2 - FULL AND OPEN COMPETITION

This scenario assumes full and rapid implementation of the transmission deregulation aspects of the EPAct and the continued aggressive policymaking at both the Federal Energy Regulatory Commission (FERC) and within key states. Under this scenario, it is assumed that tax and price subsidies for renewables are withdrawn, and that utilities are no longer able to pay above-market prices for power from any non-economic generator, whether traditional or renewable. Thus, it will be increasingly difficult for even the most sympathetic state regulatory commissions to either mandate or subsidize non-economic generation projects — even if they are willing to allow rate incentives. The reason is simple: in open electricity markets, as long as major industrial consumers are able to shop for or generate their own competitive power, the commercial and residential sectors will simply be unable or unwilling to support above-market projects and most likely will similarly defect using mechanisms such as municipalization and/or power purchasing blocks.

Wind is assumed to lose capacity from retirement of less efficient turbines installed in the 1980s, as well as from nullification of state mandates for wind power in California, New York, Vermont and Minnesota. Proposed geothermal projects classified as "speculative" are not realized. No new photovoltaic grid applications are realized, including Enron's Nevada project. Biomass, municipal solid waste and landfill gas generation is assumed to grow at 2.5% annually, which is half the rate in the Base Case.

Existing baseload plants utilizing traditional energy resources will rapidly increase generation up to capacity limits, and a new generation of low-emission, low-cost plants will begin to be built around the turn of the century. During the interim, non-utility generators are projected to increase in importance along with the advent of so-called non-utility "merchant" plants that would sell open market power on a spot or short term basis within an open electricity commodities market.

FIGURE 4-2
RDI FULL AND OPEN COMPETITION SCENARIO



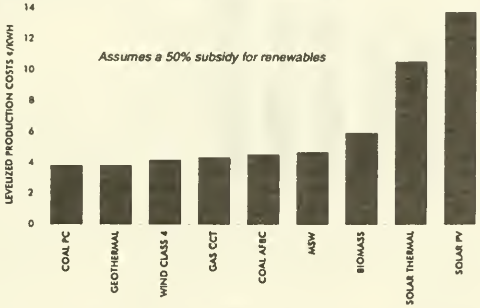
	GENERATION (BILLION KWH)				
	1993	1995	2000	3005	2010
COAL	1,674	1,730	1,867	2,033	2,153
NUCLEAR	610	659	678	679	661
HYDRO	265	272	266	268	268
NATURAL GAS	353	412	500	614	737
OIL	97	83	86	88	122
RENEWABLES:					
COMBUSTION	53	53	56	56	55
NATURALLY OCCURRING	20	20	19	16	16
TOTAL	3,072	3,229	3,472	3,754	4,011

Under this scenario, renewables fall to about 1% of the national electricity generation mix by the year 2010. As with the Base Case, waste combustion technologies drive renewables generation, given economic justification from waste disposal alternatives rather than power market economics.

SCENARIO 3 - SUBSIDY INTENSIFICATION

This scenario assumes that state and federal governments take aggressive measures to dramatically increase generation from renewable energy sources. There are two basic approaches that policy-makers can take to underwrite this growth — taxing traditional energy sources or providing sufficient subsidies to renewables to offset levelized cost differences. For a variety of reasons, many of which were discussed in an earlier RDI report (*The Costs and Implications of Controlling* CO_2 *Emissions in the U.S.* -- Prepared for the Center for the New West), the taxation approach cannot work without raising the price of all energy and stifling electricity and economic growth.[2]

FIGURE 4-3
LEVELIZED COSTS WITH SUBSIDY INTENSIFICATION FOR RENEWABLES



Hence, in order to offset the cost differential between renewables and lower coat alternatives, RDI has posited that a 50% subsidy (after first factoring out the current 1.5¢ per kilowatt hour EPAct subsidy as appropriate) would be required to adequately level the playing field — with the exception of solar, which would require either further subsidies or unanticipated technological innovation to bring it into line for grid applications.

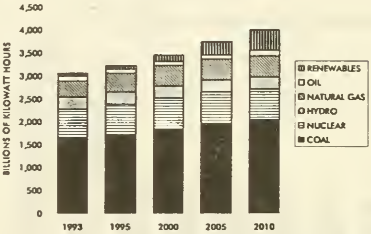
Next, assuming that the cost disadvantage of renewables can be overcome, RDI has postulated an electric generation scenario for renewables constrained primarily by technology, geography and dispatchability. For guidance, RDI relied on certain "high growth case" assumptions set forth in the National Renewable Energy Laboratory's (NREL) recent "White Paper," which explored the maximum attainable level of growth assuming that the government provided sufficient support to push renewables into a competitive position.[3] These White Paper assumptions were augmented by RDI's more recent interviews with representatives from the Laboratory, as well as technology developers and industry associations. For example, wind capacity is assumed to grow 1,500% by 2010 in order to meet targets set by the American Wind Energy Association.

Under the Subsidy Intensification scenario, renewables would grow from 75 billion kilowatt hours in 1995 to 450 billion kilowatt hours in 2010, which is an extremely aggressive growth surge wherein non-hydro renewable generation would deliver an output to the grid that would be larger than 1993's entire natural gas generation, or about three quarters of 1993's entire nuclear generation. Considering all grid generation from renewables, including traditional hydroelectric, the 2010 output of 718 billion kilowatt hours would exceed 1993's entire nuclear output by more than 20% — exceedingly ambitious by any measure.

The effect of the Subsidy Intensification scenario would be to increase non-hydro renewables generation to 4% of the generation mix by 2000, 8% by 2005 and 11% by 2010.

RDI estimated the cumulative public cost of this hypothetical Subsidy Intensification scenario by calculating the cost of the subsidies (that is, 50% of the Base Case levelized costs multiplied across the renewables' generation) for each technology on an annual basis, and then accumulating these costs over the period 1995 to 2010. The cumulative subsidies would total $203 billion (1995$) between now and 2010.

FIGURE 4-4
RDI SUBSIDY INTENSIFICATION SCENARIO



GENERATION (BILLION KWH)	1993	1995	2000	2005	2010
COAL	1,674	1,729	1,849	1,979	2,058
NUCLEAR	610	659	678	679	661
HYDRO	265	272	266	268	268
NATURAL GAS	353	409	446	450	452
OIL	97	83	86	88	122
RENEWABLES:					
COMBUSTION	53	56	81	105	129
NATURALLY OCCURRING	20	20	66	185	321
TOTAL	**3,072**	**3,229**	**3,472**	**3,754**	**4,011**

Conclusions

The three generation mix scenarios presented here are intended to bracket a range of possible futures for renewables against the backdrop of other traditional energy sources. The following table summarizes the long-term growth outlook for each major generating source over the next fifteen years under each scenario.

Under each scenario, the assumptions for nuclear, hydro and oil are held constant for reasons stated earlier. What is of interest here, however, are the tradeoffs between coal, natural gas, and non-hydro renewables.

TABLE 4-3
FORECAST SCENARIO COMPARISONS
GROWTH BY RESOURCE: 1995 TO 2010

	BILLIONS OF KWH		
	BASE CASE	**FULL & OPEN COMPETITION**	**SUBSIDY INTENSIFICATION**
COAL	396	423	329
NUCLEAR	2	2	2
HYDRO	(5)	(5)	(5)
NATURAL GAS	245	325	43
OIL	39	39	39
RENEWABLES:	-	-	-
COMBUSTION	38	3	74
NATURALLY OCCURRING	67	(4)	301
TOTAL	**782**	**782**	**782**

COAL

Under each scenario, coal garners the majority of generation growth over the coming fifteen years. First, in the period between 1995 and 2005, much of the growth in coal generation is attained through increased capacity utilization at existing baseload power plants. Some utilities will have to invest in their existing plants, particularly those that need to install environmental controls under the Clean Air Act Amendments of 1990. However, these costs are minimal in comparison to the cost of constructing new capacity, and as twenty-year old coal supply agreements (many of which tend to be priced well above market) continue to expire throughout this period, the average cost of coal will decline, further improving the economics of the existing stock of coal plants.

In some parts of the country such as the Southeast, the West and the Northeast, baseload capacity shortages will become critical as early as the 2000 to 2002 time period. This new baseload capacity should be met by coal and natural gas in roughly equal amounts (assuming that natural gas prices remain stable and that the current price differential between coal and gas remains constant over the coming 5 to 7 years) and by dispatchable renewable combustion technologies such as biomass and waste to energy.

Under the Subsidy Intensification scenario, coal loses some generation growth to renewables, but most of the displacement is from biomass and waste combustion in urban areas, primarily east of the Mississippi, and from naturally occurring resource technologies, primarily in the West. While renewables displace virtually all incremental coal projects of generally less than 100 megawatts, new coal-fired baseload capacity will still have to be installed in all regions.

NATURAL GAS

There are two major forces driving the large increase in natural gas generation under the Base Case scenario. First, utilities will continue to add gas-fired peaking and intermediate capacity for obvious reasons, including relatively low capital costs and high modularity, in addition to the fact that intermediate and peaking applications are less sensitive to fuel prices than are baseload applications. The consumption of gas in these positions will continue to grow in proportion to the growth in electric demand and peaking cycles.

Second, small power producers and electric utilities alike will continue to consider larger combined cycle natural gas units for certain baseload applications. In those regions of the country where delivered natural gas prices are lowest, natural gas plants can be dispatched as high as 65% to 75% on a year-round basis. However, where natural gas dispatch will be heavily dependent upon seasonal pricing swings (i.e., the Eastern Seaboard and the Midwest), natural gas units can be dispatched heavily only in the Summer, but still will not solve utilities' needs for increased baseload capacity during the Winter.

Under the Full and Open Competition scenario, most of the generation growth that might have otherwise gone to currently subsidized renewables is absorbed by natural gas. In spite of relatively high fuel prices, natural gas units will fill the gap left by renewable applications, which tend to be less than 100 megawatts, particularly since natural gas and renewable energy technologies tend to be more economical in the same areas of the country.

Under the Subsidy Intensification scenario, natural gas is displaced by renewables for the same reason that gas predominates under an open competition scenario — geography, modular applications, and role in the dispatch curve. Under no scenario can renewables significantly replace either baseload coal or natural gas generation. However, it will be the construction of the new stock of small, modular natural gas units over the next 5 to 7 years that will be displaced by heavily subsidized renewable units. During the same period, coal generation should continue to grow through increased capacity utilization and construction of new plants to meet increased baseload demand.

RENEWABLES

Combustion technologies represent over 70% of all existing electricity generators designated as "renewable" and will grow significantly under the Base Case scenario. Although they have no clear environmental advantages over traditional technologies on an operating basis (all combustion technologies present emissions), renewable combustion technologies will be developed in response to increased waste disposal costs arising from tightening regulations regarding landfilling and open air burning.

Efforts to develop biomass generators based on dedicated energy crops, in place of agricultural and lumber waste, will not be developed under any energy scenario for a number of reasons. First, few sites provide enough land for energy crop cultivation, transmission access, and adequate water supplies. Second, fuel costs for dedicated energy crops are estimated to be up to 300% more expensive than costs for waste fuelstocks. Finally, it has not been proven that the public finds cultivation of forests for the sole purpose of combustion to be environmentally attractive.

The non-combustion resources, wind, solar, and geothermal, will increasingly be exploited under the Base Case scenario as the result of state mandates and set-asides. Much of the new capacity in wind and solar will consist of demonstration projects that will contribute very little to the overall electricity supply in a given utility territory.

Niche projects in both wind and geothermal, however, will take advantage of pockets of strong energy resources, such as wind regimes of class 6 and above or hydrothermal fields with temperatures well above 300°F, to provide meaningful and economical electricity production. These projects will be relatively small and dispersed throughout remote areas of the West. As such, they will be the exception rather than the rule. In general, wind, solar, and geothermal plant development will struggle with the many practical and economic constraints discussed in this study.

Under a Full and Open Competition scenario, very few new renewable applications will find their way into the market because they remain expensive. The small net growth projected for combustion technologies is a result of the phasing out of non-economical 1980s projects and a slow replacement with waste to energy projects in those areas of the country where burning is the only disposal option. Without subsidies of one kind or another, very few scenarios are available in which non-combustion renewable generation can grow.

Under a Subsidy Intensification scenario, both combustion and non-combustion renewable generation grow significantly. However, it is assumed that the non-combustion technologies will enjoy the majority of the growth, particularly in the later years, as heavy research subsidies begin to produce economic solar technology designs and more economic wind designs. This scenario incorporates the most aggressive assumptions from the renewables community concerning the amount of renewable capacity that could be built. Nevertheless, resource availability and intermittence limitations will continue to prevent solar and wind from entering baseload positions, and the displacement of new natural gas units by wind and solar will be softened to a degree by the intermittent technologies' need for natural gas back-up generation.

Technical Appendix

Introduction

This Technical Appendix to the study provides an explanation of the methodology behind RDI's levelized cost analysis, sources of information relied upon by RDI in performing the analysis, specific technologies chosen for comparative purposes, sensitivity analyses to test the bounds of certain assumptions, and a presentation of the coal and natural gas price forecasts employed in determining levelized costs. For further review of RDI's methods and assumption, an interactive levelized cost model and the raw data used in this study are available in an Excel™ 5.0 format at a cost of $50.00 (contact CEED at the address provided in the front of this study).

RDI recognizes that the actual levelized costs of individual power projects will depend on site-specific circumstances. As such, the information, analysis, and methodology found in this study are meant to provide a general and relative comparison of the various generating technologies. Some of the assumptions made here may not be appropriate for an actual project, but provide a meaningful framework to examine the issues more broadly on a regional and national basis.

The study seeks to account for the most significant factors including the following:

- Regional fuel, capital, and labor costs
- Changes in fuel prices over the next 20 years
- Tax incentives and other direct subsidies
- Discount rates
- Capacity utilization rates.

Data Sources

RDI consulted a variety of sources for cost and operating information on current and future electricity generating technologies, including both academic and professional publications. In addition, RDI contacted the key players in the research, development, and application of these technologies to obtain the most current and accurate information possible. Except where noted, RDI relied upon EPRI's 1993 *Technical Assessment Guide* (TAG) and the International Energy Agency's *Guidelines for the Economic Analysis of Renewable Energy Technology Applications* (IEA *Guidelines*) to determine capital and operating costs, as well as operating parameters.

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In addition, RDI maintains two proprietary database products, POWERdat® and COALdat®, which provided all of the historical financial and operational data for the coal and power industries used in this study. Both databases consist of electricity generation, fuel purchasing, and power sales information filed by electric utilities with the Federal Energy Regulatory Commission (FERC) and the Energy Information Administration (EIA), among other sources.

INSTITUTIONS CONTACTED BY RDI

- AMERICAN SOLAR ENERGY SOCIETY
- AMERICAN WIND ENERGY ASSOCIATION
- CALIFORNIA BIOMASS ENERGY ALLIANCE
- CALIFORNIA ENERGY COMMISSSION
- ENERGY INFORMATION ADMINISTRATION
- GEOTHERMAL ENERGY ASSOCIATION
- GEOTHERMAL RESOURCES COUNCIL
- NATIONAL RENEWABLE ENERGY LABORATORY
- NORTHWEST POWER PLANNING COUNCIL
- SELECTED BOILER MANUFACTURERS
- U.S. DEPARTMENT OF ENERGY
- UTILITY WIND INTEREST GROUP

Plant Costs

All cost information is in constant 1993 dollars mainly because inflation forecasts would introduce an additional variable and increase uncertainty. Plant costs in this study consist of the overnight plant construction costs, fixed and variable operating costs, fuel costs, and replacement costs.

OVERNIGHT PLANT CONSTRUCTION COSTS

Overnight plant construction costs reflect the cost of materials and labor to construct an entire plant "overnight" in constant 1993 dollars. Cost assumptions are all engineering estimates for actual, proposed, or hypothetical projects obtained from the EPRI TAG, industry papers, and technology vendors. The assumption of "overnight" construction removes capital cost escalation and financing during construction time from consideration in the analysis. Nevertheless, differences in costs during construction exist between technologies. For example, a wind farm project may be constructed incrementally over ten years with capacity coming on-line as completed, while a large coal plant may require two or three years of construction prior to operation. Sensitivity of the levelized cost analysis to the assumption of overnight construction is explored later in this Technical Appendix.

FIXED OPERATING COSTS

Fixed operating costs are independent of plant generation and expressed in dollars per kilowatt-year. Fixed costs typically include operating labor, maintenance, and overhead. A fraction of the total labor is referred to as operating jobs, which are the minimum set of jobs required to operate the plant. Similarly, a portion of the cost of maintenance of many systems is independent of plant production, such as maintaining processing systems for corrosive and abrasive slurries, fuel handling, electrical and steam systems. Overhead charges consist chiefly of administrative and support labor.

VARIABLE OPERATING COSTS

Variable operating costs are proportionate to the amount of electricity generated and are expressed here in cents per kilowatt hour (¢/kWh). Consumables such as water, chemicals, and other materials constitute the major components of variable operating costs. These may include raw water for steam and cooling, sorbent for desulfurization (lime, limestone, soda ash), ammonia for low NO_x burning, fabric filter bags for bag houses, and other catalysts and solvents. Some by-products may be marketable such as coal ash, sulfur, sulfuric acid, gypsum, and liquid sulfur dioxide and, therefore, may represent a variable operating credit. Other variable costs may include disposal charges for ash and scrubber waste, as well as steam and electric charges for in-house use.

FUEL COSTS

The cost of fuel is determined by multiplying the price of fuel delivered to a power plant site for consumption, as expressed in dollars per million Btu ($/mmBtu), by the amount of fuel burned during the year. Wind, solar, and hydrothermal energy are considered free fuel sources in this study. Price forecasts for coal and natural gas are provided later in this Technical Appendix.

REPLACEMENT COSTS

Some technology characterizations recognize that the system will need major overhaul or replacement parts at some point in its service life. For example, wind farms will usually need new parts after 8 and 20 years of service. These costs are treated separately, rather than lumping them with overnight capital costs or with fixed O&M costs.

Operating Data

A variety of other operational parameters must be considered in order to estimate levelized costs and to adequately portray the technology type. The table on the right lists the data collected in this study relative to operational performance. Not all variables are applicable or available for all technologies. The two critical operational parameters examined here are heat rates and capacity factors.

OPERATIONAL PARAMETERS

- ENERGY SOURCE
- SPECIFIC TECHNOLOGY DESCRIPTION
- REGION
- FULL LOAD HEAT RATE
- AVERAGE ANNUAL HEAT RATE
- SYSTEM EFFICIENCY
- CAPACITY FACTOR
- AVAILABILITY
- CAPABILITY RATIO
- BOOK/SERVICE LIFE OF ASSET
- TAX LIFE OF ASSET
- UNIT SIZE (MW)
- VINTAGE
- LAND AREA
- WIND CLASS
- TOTAL SOLAR INSOLATION
- DIRECT BEAM INSOLATION

HEAT RATES AND EFFICIENCY

Heat rate is a measurement of efficiency for combustion technologies based on the amount of fuel, measured in Btu's, required to produce one kilowatt hour of electricity. Heat rates should not be confused with the heat content of fuels. A lower heat rate indicates a higher level of technological efficiency whereby less fuel is required to generate electricity, assuming a constant fuel heat content. Conversely, a higher number of Btu's in a fuel's heat content indicates that less fuel is required to generate electricity, assuming a constant technological heat rate. Heat rates directly impact plant efficiency and are critical in assessing levelized costs. The following rates have been assumed in the levelized cost analyses and have been obtained from the EPRI TAG and other industry sources.

ASSUMED HEAT RATES OF VARIOUS TECHNOLOGIES

TECHNOLOGY	HEAT RATE BTU/KWH
PULVERIZED COAL-BITUMINOUS	9,550
PULVERIZED COAL-SUBBITUMINOUS	10,268
ATMOSPHERIC FLUIDIZED-BED COMBUSTION	10,377
NATURAL GAS COMBINED CYCLE	7,520
BIOMASS	14,280
MUNICIPAL SOLID WASTE (MSW)	16,870

CAPACITY FACTORS

The capacity factor (also called "capacity utilization") of a plant is a measure of the plant's performance. It relates the annual output of the plant relative to its potential output. Plant capacity factors are calculated as follows:

$$\text{Capacity Factor} = \frac{\text{Annual Net Generation (MWh/Year)}}{\text{Nameplate Capacity (MW)} \times 8{,}760 \text{ (Hours/Year)}}$$

RDI sought to use capacity factors that would reflect actual historical data for the type of generating asset, as well as the role that they are expected to play in the future. Derivation of each capacity factor used in the base case is discussed below. The sensitivity of levelized cost estimates to the capacity factor is presented later in this Technical Appendix.

- **COAL PLANTS:** Capacity factor assumptions of 80% for pulverized coal (PC) plants and 70% for fluidized-bed (AFBC) plants are based on the historical operation of coal-fired units, as reported by RDI's POWERdat® database. The top 100 utility coal units, as ranked by their capacity factors in 1993, yielded an average capacity factor of 76%, while the top 50 yielded an average capacity factor of 80%.

TOP 50 COAL PLANTS IN TERMS OF 1993 CAPACITY FACTORS

RANK	UTILITY	PLANT	STATE	YEAR LAST UNIT CAME ONLINE	CAPACITY FACTOR	INSTALLED CAPACITY (MW)
1	SAN ANTONIO PUBLIC SERVICE	J.K. SPRUCE	TX	1992	98%	500
2	PACIFICORP	WYODAK	WY	1978	90%	362
3	PLATTE RIVER POWER AUTHORITY	RAWHIDE	CO	1984	90%	255
4	CENTRAL POWER & LIGHT CO.	COLETO CREEK	TX	1980	90%	600
5	COLORADO SPRINGS UTILITIES	NIXON	CO	1980	88%	207
6	JACKSONVILLE ELECTRIC AUTH	ST. JOHNS RIVER POWER	FL	1988	87%	1,359
7	BASIN ELECTRIC POWER COOP	ANTELOPE VALLEY	ND	1986	86%	870
8	UTILICORP UNITED, INC.	CLARK (CO)	CO	1959	86%	39
9	DESERET GENERATION & TRAN COOP	BONANZA	UT	1986	86%	400
10	PENNSYLVANIA POWER & LIGHT CO.	HOLTWOOD	PA	1954	85%	75
11	NEW YORK STATE ELEC & GAS CORP	ALLEN E. KINTIGH (SOMERSET)	NY	1984	85%	692
12	PACIFICORP	JOHNSTON	WY	1972	84%	817
13	INTERMOUNTAIN POWER AGENCY	INTERMOUNTAIN GENERATING	UT	1987	83%	1,640
14	COOPERATIVE POWER ASSN	COAL CREEK	ND	1981	83%	1,100
15	MONTANA POWER CO.	CORETTE	MT	1968	83%	163
16	SOUTHWESTERN PUBLIC SERVICE CO	HARRINGTON	TX	1980	83%	1,080
17	PSC OF COLORADO	CAMEO	CO	1960	83%	66
18	SOUTHERN INDIANA GAS & ELECTRI	WARRICK	IN	1970	83%	744
19	TEXAS MUNICIPAL POWER AGENCY	GIBBONS CREEK	TX	1983	82%	408
20	PACIFICORP	CARBON	UT	1957	82%	189
21	TEXAS UTILITIES ELECTRIC CO.	SANDOW 4	TX	1981	82%	591
22	MINNKOTA POWER COOP, INC.	YOUNG	ND	1977	82%	673
23	PACIFICORP	HUNTINGTON	UT	1977	81%	893
24	SAN MIGUEL ELECTRIC COOP, INC.	SAN MIGUEL	TX	1982	81%	409
25	SALT RIVER PROJECT	NAVAJO	AZ	1976	80%	2,409
26	BIG RIVERS ELECTRIC CORP	WILSON	KY	1986	80%	440
27	SOUTH CAROLINA PUB SERV AUTH	CROSS	SC	1984	80%	556
28	PACIFICORP	HUNTER	UT	1983	79%	1,339
29	INDIANA-KENTUCKY ELECTRIC CORP	CLIFTY CREEK	IN	1956	79%	1,304
30	WEST TEXAS UTILITIES CO.	OKLAUNION	TX	1986	79%	720
31	PACIFICORP	BRIDGER	WY	1979	79%	2,173
32	BLACK HILLS CORP	OSAGE	WY	1952	79%	35
33	ALABAMA POWER CO.	GREENE COUNTY	AL	1966	78%	569
34	WEST PENN POWER CO.	ARMSTRONG	PA	1984	78%	326
35	OHIO VALLEY ELECTRIC CORP	KYGER CREEK	OH	1955	78%	1,086
36	CONSUMERS POWER CO.	WEADOCK	MI	1958	77%	313
37	OHIO POWER CO	KAMMER	WV	1959	77%	713
38	TRI-STATE G & T ASSN, INC.	CRAIG	CO	1984	77%	1,333
39	TUCSON ELECTRIC POWER CO.	SPRINGERVILLE	AZ	1990	77%	794
40	TEXAS-NEW MEXICO POWER CO	TNP ONE	TX	1991	77%	349
41	SOUTHWESTERN PUBLIC SERVICE CO	TOLK	TX	1985	77%	1,136
42	TENNESSEE VALLEY AUTHORITY	CUMBERLAND	TN	1973	77%	2,600
43	TENNESSEE VALLEY AUTHORITY	JOHN SEVIER	TN	1957	76%	800
44	ARIZONA PUBLIC SERVICE CO.	FOUR CORNERS	NM	1970	76%	2,249
45	CINCINNATI GAS & ELECTRIC CO	W.H. ZIMMER	OH	1990	75%	1,426
46	TEXAS UTILITIES ELECTRIC CO	MARTIN LAKE	TX	1979	75%	2,380
47	SOUTH CAROLINA ELECTRIC & GAS	WILLIAMS-ST	SC	1973	75%	633
48	SAN ANTONIO PUBLIC SERVICE	DEELY	TX	1978	75%	836
49	ELECTRIC ENERGY, INC.	JOPPA	IL	1955	75%	1,100
50	NORTHERN STATES POWER CO (MN)	SHERBURNE	MN	1987	74%	2,279
				AVERAGE CAPACITY FACTOR	**81%**	**44,027**
				CAPACITY FACTOR WEIGHTED AVERAGE	**80%**	
				AVERAGE CAPACITY IN MW		**881**

NATURAL GAS COMBINED CYCLE PLANTS: The 65% capacity factor used in this study is based on the historical operation of combined cycle units, as reported by RDI's POWERdat® database. Only five natural gas combined cycle plants were operated at a capacity factor of 65% or greater in 1994, as seen in the table below. After examining the historical capacity factors in that table and after considering the trends discussed on page 4-3, RDI chose the aforementioned value based on the assumption that any hypothetical new combined cycle gas unit would be built for baseload applications.

Although it is technically feasible to run combined cycle gas units at full capacity, actual performance will depend on the relative price of available fuel. As discussed later in this Technical Appendix, real prices of natural gas are expected to rise, whereas the real prices of coal are expected to remain stable or actually fall. This implies that any existing or new gas plants may not be dispatched at higher capacity factors throughout their lives due to increasing fuel costs. This study assumes a constant annual capacity factor for all technologies.

ALL OPERATING NATURAL GAS COMBINED CYCLE UNITS

SOME COMBINED-CYCLE PLANTS HAVE BEEN EXCLUDED BECAUSE THE PLANT EITHER PRIMARILY BURNED OIL OR GENERATED AT LESS THAN A 1% CAPACITY FACTOR IN 1994

CENSUS REGION UTILITY	PLANT	STATE	YEAR LAST UNIT CAME ON-LINE	CAPACITY FACTOR	NAMEPLATE CAPACITY (MW)	1994 NET GENERATION (MWH)
EAST SOUTH CENTRAL						
CLARKSDALE PUBLIC UTILS COMM	WILKINS	MS	1971	35%	26	79,420
MIDDLE ATLANTIC						
JERSEY CENTRAL POWER & LIGHT	GILBERT	NJ	1977	14%	350	433,940
NEW YORK POWER AUTHORITY	HOLTSVILLE CC PLANT	NY	1994	53%	141	732,980
MOUNTAIN						
ARIZONA PUBLIC SERVICE CO	WEST PHOENIX	AZ	1976	21%	396	722,681
SALT RIVER PROJECT	SANTAN	AZ	1975	7%	414	267,962
FARMINGTON ELECTRIC UTILITY	ANIMAS	NM	1993	55%	25	118,703
NEVADA POWER CO	CLARK	NV	1982	17%	528	793,646
NEW ENGLAND						
BRAINTREE ELECTRIC LIGHT DEPT	POTTER STATION 2	MA	1977	10%	96	81,594
TAUNTON MUN LIGHTING PLANT	CLEARY FLOOD	MA	1976	7%	118	75,760
PACIFIC						
CHUGACH ELECTRIC ASSN, INC.	BELUGA	AK	1982	67%	238	1,392,895
ANCHORAGE MUN. LIGHT & POWER	GEORGE M SULLIVAN	AK	1979	42%	174	631,997
SOUTHERN CALIFORNIA EDISON CO.	COOL WATER	CA	1978	21%	580	1,089,953
SOUTHERN CALIFORNIA EDISON CO.	LONG BEACH	CA	1977	3%	650	184,098
GLENDALE PUBLIC SERVICE DEPT.	GRAYSON	CA	1977	4%	123	43,072
PORTLAND GENERAL ELECTRIC CO	BEAVER	OR	1977	54%	566	2,754,946
SOUTH ATLANTIC						
DELMARVA POWER & LIGHT CO.	HAY ROAD	DE	1993	43%	471	1,735,359
FLORIDA POWER & LIGHT CO.	LAUDERDALE	FL	1958	65%	1,048	5,923,554
FLORIDA POWER & LIGHT CO.	MARTIN	FL	1994	75%	905	5,909,845
FLORIDA POWER & LIGHT CO.	PUTNAM	FL	1978	42%	580	3,125,808
FORT PIERCE UTILITIES AUTH	HENRY D KING	FL	1990	16%	31	42,909
KISSIMMEE UTILITY AUTHORITY	HANSEL	FL	1982	45%	48	186,822
LAKE WORTH UTILITIES (CITY OF)	TOM G SMITH	FL	1978	54%	31	148,672
VERO BEACH MUNICIPAL UTILITIES	VERO BEACH MUNICIPAL	FL	1964	66%	58	333,753
FAYETTEVILLE PUBLIC WORKS COMM	BUTLER WARNER GEN PL	NC	1988	3%	346	64,990
VIRGINIA ELECTRIC & POWER CO	CHESTERFIELD	VA	1993	53%	438	3,044,435
WEST SOUTH CENTRAL						
OKLAHOMA GAS & ELECTRIC CO.	HORSESHOE LAKE	OK	1963	46%	347	987,199
PSC OF OKLAHOMA	COMANCHE	OK	1974	48%	390	1,232,930
WESTERN FARMERS ELEC COOP	ANADARKO	OK	1977	50%	300	1,310,723
EL PASO ELECTRIC CO	NEWMAN	TX	1975	34%	290	865,590
HOUSTON LIGHTING & POWER CO.	T.H. WHARTON	TX	1974	23%	647	1,299,841
WEST TEXAS UTILITIES CO.	RIO PECOS	TX	1959	53%	43	197,527
WEST TEXAS UTILITIES CO.	SAN ANGELO	TX	1966	80%	133	940,621
AVERAGE CAPACITY FACTOR				38%		
CAPACITY FACTOR WEIGHTED AVERAGE				39%		
TOTAL CAPACITY					10,266	

Source: RDI POWERdat, 1995.

WIND TURBINES: Wind capacity factors are based on the wind class for the site. Therefore, both wind classes 4 and 5 are illustrated. Because wind classes 6 and 7 are fairly uncommon, they have not been considered in the comparative levelized cost analyses in this study. A reference table for capacity factors relative to wind class is shown on the right.

WIND SPEED CLASS MIDPOINTS (M/S)

WIND CLASS	WIND FOR HUB HEIGHT 10M	30M	CAPACITY FACTOR	GROSS ENERGY/100KW (KWH)
1	4.4	5.1	0.13	113,100
2	5.1	5.9	0.20	171,400
3	5.6	6.5	0.25	219,500
4	6.0	7.0	0.29	257,300
5	6.4	7.4	0.33	287,600
6	7.0	8.2	0.39	341,900
7	9.4	11.0	0.56	490,700

Source: EPRI TAG, 1993, p.8-105

BIOMASS AND MUNICIPAL SOLID WASTE (MSW) PLANTS: Capacity factors for these technologies were assumed at 70% in order to reflect their operation as baseload units. This assumption is supported by the familiarity of the combustion technology, which is very similar to coal combustion technologies. Differences between coal and biomass or MSW plants exist primarily in fuel handling systems. Capacity factors for biomass plants may be lower in actual applications due to the seasonality of fuel availability or swings in the markets for the agriculture/lumber products generating the fuel residues.

SOLAR GENERATORS: Solar capacity factors are based on the availability of the energy resource. Solar insolation data for 26 cities were used to derive the regional capacity factors for solar photovoltaic systems. Direct beam solar insolation information is used for the solar thermal capacity factors.

Cost of Energy Calculations

Levelized analysis is used to compare the feasibility of different types of generating assets where costs are distributed differently over the asset's service life. Some technologies, such as photovoltaics, have high initial capital costs and low operating costs over the unit's life. Other types of electric plants may have high or volatile fuel costs, such as an oil-fired unit. Levelized cost analysis provides a means for comparing technologies on the same basis by spreading out all costs involved in building the facility and producing electricity over the life of the facility. Detailed calculations for determining levelized costs are provided in the equations following. The math is somewhat simplified by some general assumptions. All costs and prices are in constant 1993 dollars; that is, there is no inflation. Additionally, there is no real escalation of any costs except for fuel prices (see discussion on fuel price forecasts later in this section). The methodology used in this report is consistent with IEA and EPRI principles for levelized costs. The basic equation for the levelized cost of energy is:

$$\text{Levelized Fixed Charge Rate} = \frac{\text{Fixed Charge Rate} \times \text{Overnight Plant Cost} + \text{Levelized O\&M Cost} + \text{Levelized Fuel Cost}}{\text{Annual Energy Output}}$$

where the Cost of Energy is expressed in constant dollars per kW-year or alternatively in cents per kWh. Each variable in the levelized cost of energy equation is discussed in turn below.

FIXED CHARGE RATE

The fixed charge rate is the mechanism that distributes the cost of the plant and capital over the life of the asset. The rate incorporates the time value of money, federal and state income taxes, property taxes, and depreciation expenses. The levelized fixed charge rate is calculated as follows:

$$\text{Levelized Fixed Charge Rate} = \frac{1 - \frac{1}{\text{tax life}} \cdot (\text{combined tax rate}) \cdot \left(\sum_{t=1}^{\text{tax life}} \frac{\text{accdeprn rate}_t}{(1+\text{discount rate})^t} \right)}{(1 - \text{combined tax rate}) \cdot \left(\sum_{j=1}^{\text{book life}} \frac{\text{deprn rate}_j}{(1+\text{discount rate})^j} \right)} + \left(\begin{matrix} \text{property} \\ \text{tax rate} \end{matrix} \right) + \left(\begin{matrix} \text{insurance} \\ \text{rate} \end{matrix} \right)$$

where,

accdeprn rate is the accelerated depreciation rate in year t,
deprn rate is the straight-line depreciation rate in year j.

The fixed charge rate is calculated in this manner because the Accelerated Cost Recovery System under current tax laws allows the depreciation of an asset for tax purposes at a rate faster than that used for book value of the asset. This study uses the double-declining balance method of calculating accelerated depreciation. The table on the right provides a comparison of book life and tax life for the various technologies.

COMPARATIVE TAX LIFE OF ENERGY TECHNOLOGIES

	ASSET TAX LIFE (YRS)	ASSET BOOK LIFE (YRS)
COAL	20	30
NATURAL GAS	20	30
BIOMASS	15	30
GEOTHERMAL	15	30
MSW	15	20
SOLAR PV	5	30
SOLAR THERMAL	5	30
WIND	5	30

OVERNIGHT PLANT COST

Overnight plant cost, as described earlier, is the total cost of the plant excluding land and interest during construction

LEVELIZED OPERATING AND MAINTENANCE COST

Levelized operating and maintenance cost are calculated as:

$$\begin{pmatrix}\text{Levelized}\\ \text{O\&M Costs}\end{pmatrix}\left[\frac{\$}{\text{kw-year}}\right]=\begin{pmatrix}\text{Variable}\\ \text{O\&M Costs [cents/kwh]}\end{pmatrix}\bullet\left(0.01\left[\frac{\$}{\text{cent}}\right]\right)\bullet\begin{pmatrix}\text{Capacity}\\ \text{Factor}\end{pmatrix}\bullet\left(8760\left[\frac{\text{hours}}{\text{year}}\right]\right)+\left(\text{Fixed O\&M Costs}\left[\frac{\$}{\text{kW-year}}\right]\right)$$

LEVELIZED FUEL COST

Using fuel price forecasts presented later in this Technical Appendix the cost of fuel is calculated as:

$$\text{Levelized Fuel Cost}=\sum_{t=1}^{\text{service life}}\frac{\begin{pmatrix}\text{Average Annual}\\ \text{Heat Rate}\end{pmatrix}\bullet\begin{pmatrix}\text{Capacity}\\ \text{Factor}\end{pmatrix}\bullet\left(8760\left[\frac{\text{hours}}{\text{year}}\right]\right)\begin{pmatrix}\text{Delivered}\\ \text{Fuel Price}_t\end{pmatrix}}{(1+\text{discount rate})^t}\times\left(\frac{\text{discount rate}\bullet(1+\text{discount rate})^{\text{service life}}}{(1+\text{discount rate})^{\text{service life}}-1}\right)$$

where service life is the book life of the generating asset.

ANNUAL ENERGY OUTPUT

Annual energy output is a function of the capacity factor and the capacity of the generating unit.

Technology Selections and Analysis

RDI considered various technologies appropriate to each energy resource and chose those technologies for levelized cost comparison that represented the most likely case for new plant construction as of 1995. For example, natural gas combined cycle designs are considered economically more attractive today than are traditional natural gas turbine designs. Geothermal dry steam plants are based on a hydrothermal resource that is concentrated at The Geysers in California, an area already heavily exploited for electricity generation. Therefore, new development will likely occur outside The Geysers where different resources will require different technologies, such as Flash and Binary Cycle.

he specific technologies and designs chosen for levelized cost comparison in this study clude:

- Pulverized coal (PC) plant with wet flue gas desulfurization located in the Southeast. One 400 megawatt unit burning bituminous coal, annual capacity factor of 80%.

- Atmospheric fluidized bed combustion (AFBC) coal plant located anywhere in the U.S. One 200 megawatt unit burning bituminous coal, with an annual capacity factor of 70%.

- Natural gas combined cycle unit located anywhere in the U.S. 225 megawatt capacity running at annual capacity factor of 65%.

- Wind variable speed 0.2 megawatt turbine located in a Class 4 wind regime. Technology is NREL Concept 1 with control electronics and advanced design airfoils placed on a 50 meter tower. Annual capacity factor assumed at 29%.

- Biomass fluidized bed combustor burning wood and located in the West. One 50 megawatt unit operating at an annual capacity factor of 70%.

- Waste-to-energy MSW mass burn plant located in the West. 40 megawatts operating at an annual capacity factor of 70%.

- Geothermal double flash plant located in the West. 1 to 25 megawatt unit operating at an annual capacity factor of 90%.

- Solar flat plate Pv located in the West. 50 megawatt capacity. Capacity factor not applicable.

- Solar thermal parabolic trough located in the West. 80 megawatt capacity operating at a 40% annual capacity factor.

list of all 120 technologies and technology designs considered in this study, as well as erating variations, is provided on the next two pages.

LIST OF TECHNOLOGIES AND TECHNOLOGY VARIATIONS EXAMINED

RESOURCE	TECHNOLOGY
BIOMASS	WHOLE TREE PROGRAM PLANT - MINN. POWER
BIOMASS	WHOLE TREE PROGRAM PLANT - RTI STUDY
BIOMASS	WHOLE TREE PROGRAM PLANT - APPEL CONSULTANTS
BIOMASS	WHOLE TREE PROGRAM PLANT - EPRI
BIOMASS	WOOD-FIRED ELECTRIC UTILITY PLANT -ASES
BIOMASS	WOOD-FIRED STOKER
BIOMASS	WOOD-FIRED FLUIDIZED BED COMBUSTION
BIOMASS	WOOD-FIRED GASIFICATION/COMBINED-CYCLE CONVENTIONAL
BIOMASS	WOOD-FIRED GASIFICATION/COMBINED-CYCLE ADVANCED
COAL	PULVERIZED COAL, SUBCRITICAL/LIMESTONE FORCED OXIDATION - BITUMINOUS COAL (300MW)
COAL	PULVERIZED COAL, SUBCRITICAL/LIMESTONE FORCED OXIDATION - BITUMINOUS COAL (500MW)
COAL	ATMOSPHERIC FLUIDIZED-BED COMBUSTION - CIRCULATING, BITUMINOUS
COAL	SUBCRITICAL, BASE & CYCLING, BITUMINOUS
COAL	ATMOSPHERIC FLUIDIZED-BED COMBUSTION - BUBBLING - BITUMINOUS
COAL	PULVERIZED COAL - LIME SPRAY DRYER - SUBCRITICAL - BITUMINOUS
COAL	PULVERIZED COAL - LIME SPRAY DRYER - SUBCRITICAL - SUBBITUMINOUS
COAL	PULVERIZED COAL/SUBCRITICAL/LIMESTONE FORCED OXIDATION - BITUMINOUS COAL(300MW)
COAL	PULVERIZED COAL/SUBCRITICAL/LIMESTONE FORCED OXIDATION - BITUMINOUS COAL(300MW)
COAL	PULVERIZED COAL - WELLMAN LORD - SUBCRITICAL - BITUMINOUS
COAL	PULVERIZED COAL - SUPERCRITICAL - SUBBITUMINOUS
COAL	PULVERIZED COAL - LIME SPRAY DRYER - SUBCRITICAL - LIGNITE
COAL	PULVERIZED COAL - SUPERCRITICAL - BITUMINOUS COAL
COAL	ATMOSPHERIC FLUIDIZED-BED COMBUSTION - CIRCULATING - SUBBITUMINOUS
COAL	SUBCRITICAL, BASE & CYCLING, WEST CENTRAL - SUBBITUMINOUS
COAL	SUPERCRITICAL, BASELOAD, EAST/WEST CENTRAL - SUBBITUMINOUS
COAL	ATMOSPHERIC FLUIDIZED-BED COMBUSTION - CIRCULATING - LIGNITE
COAL	ATMOSPHERIC FLUIDIZED-BED COMBUSTION - CIRCULATING - BITUMINOUS
COAL	SUBCRITICAL, BASE & CYCLING, WEST CENTRAL - BITUMINOUS
COAL	SUBCRITICAL, BASE & CYCLING, NORTHEAST - BITUMINOUS
COAL	SUPERCRITICAL, BASELOAD, NORTHEAST - BITUMINOUS
COAL	SUBCRITICAL, BASE & CYCLING, SOUTH CENTRAL - LIGNITE
COAL	NEW COAL-FIRED PLANT WITH SOX AND NOX CONTROLS
COAL	PULVERIZED COAL - WET FGD - BITUMINOUS COAL (400MW)
COAL	PULVERIZED COAL - WET FGD - BITUMINOUS COAL (2 X 400MW)
COAL	ATMOSPHERIC FLUIDIZED-BED COMBUSTION - CIRCULATING (2X400MW)
COAL	PULVERIZED COAL - SPRAY DRYER FGD - SUBBITUMINOUS COAL
GEOTHERMAL	BINARY - EPRI (1989)
GEOTHERMAL	BINARY (>25MW) - LOW
GEOTHERMAL	BINARY (>25MW) - HIGH
GEOTHERMAL	BINARY (1.5 TO 25MW) - LOW
GEOTHERMAL	BINARY (1.5 TO 25MW) - HIGH
GEOTHERMAL	BINARY (.2 TO 1.5MW) - LOW
GEOTHERMAL	BINARY (.2 TO 1.5MW) - HIGH
GEOTHERMAL	DOUBLE FLASH (>25MW) - LOW
GEOTHERMAL	DOUBLE FLASH (>25MW) - HIGH
GEOTHERMAL	DOUBLE FLASH (10 TO 25MW) - LOW
GEOTHERMAL	DOUBLE FLASH (10 TO 25MW) - HIGH
GEOTHERMAL	DRY STEAM - EPRI (1989)
GEOTHERMAL	DRY STEAM (>25MW) - LOW
GEOTHERMAL	DRY STEAM (>25MW) - HIGH
GEOTHERMAL	DRY STEAM (5 TO 10MW) - LOW
GEOTHERMAL	DRY STEAM (5 TO 10MW) - HIGH
GEOTHERMAL	*SINGLE FLASH (>25MW) - LOW
GEOTHERMAL	*SINGLE FLASH (>25MW) - HIGH
GEOTHERMAL	*SINGLE FLASH (5 TO 15MW) - LOW
GEOTHERMAL	*SINGLE FLASH (5 TO 15MW) - HIGH
GEOTHERMAL	*SINGLE FLASH (0.2 TO 5MW) - LOW
GEOTHERMAL	*SINGLE FLASH (0.2 TO 5MW) - HIGH
GEOTHERMAL	BINARY - EPRI (1993)
GEOTHERMAL	DUAL FLASH - EPRI (1993)

(CONTINUED ON FOLLOWING PAGE)

LIST OF TECHNOLOGIES AND TECHNOLOGY VARIATIONS EXAMINED (CONT'D)

RESOURCE	TECHNOLOGY
MSW	MUNICIPAL SOLID WASTE - MASS BURN (1989)
MSW	MUNICIPAL SOLID WASTE - REFUSE DERIVED FUEL (1989)
MSW	MUNICIPAL SOLID WASTE MASS BURNING (1993)
MSW	REFUSE DERIVED FUEL-FIRED STOKER (1993)
MSW	SCRAP TIRE-FIRED MASS BURN BOILER (1993)
NATURAL GAS	DRAFT COMBINED-CYCLE COMBUSTINE TURBINE
NATURAL GAS	COMBUSTION TURBINE - HEAVY DUTY - PEAKING UNIT (150MW)
NATURAL GAS	COMBUSTION TURBINE - HEAVY DUTY - PEAKING UNIT (100MW)
NATURAL GAS	COMBUSTION TURBINE - HEAVY DUTY - PEAKING UNIT (80MW)
NATURAL GAS	COMBUSTION TURBINE - HEAVY DUTY - PEAKING UNIT (50MW)
NATURAL GAS	COMBUSTION TURBINE - STIG - INTERMEDIATE UNIT (50MW)
NATURAL GAS	COMBINED-CYCLE PLANT
NATURAL GAS	COMBUSTION TURBINE/COMBINED CYCLE - BASELOAD UNIT (225MW)
SOLAR PV	CENTRALIZED FACILITY - FILM PV - ASES (2000)
SOLAR PV	FLAT PLATE - EPRI 1989
SOLAR PV	HIGH CONCENTRATION - EPRI 1989
SOLAR PV	CENRALIZED FACILITY - SILICON - CRYSTAL -ASES
SOLAR PV	FIXED FLAT PLATE (5MW) WEST - 1997
SOLAR PV	FIXED FLAT PLATE (50MW) WEST - 1997
SOLAR PV	FIXED FLAT PLATE (5MW) SOUTHEAST - 1997
SOLAR PV	FIXED FLAT PLATE (50MW) SOUTHEAST - 1997
SOLAR PV	FRESNEL LENS HIGH CONCENTRATION (5MW) - 2000
SOLAR PV	FRESNEL LENS HIGH CONCENTRATION (50MW) - 2000
SOLAR PV	CENTRAL STATION PV/FLAT PLATE - 1995
SOLAR PV	CENTRAL STATION PV/FLAT PLATE - 2000
SOLAR PV	CENTRAL STATION PV/FLAT PLATE - 2010
SOLAR PV	PV CONCENTRATOR - 1995
SOLAR PV	PV CONCENTRATOR - 2000
SOLAR PV	PV CONCENTRATOR - 2010
SOLAR THERMAL	SOLAR PARABOLIC TROUGH - GAS HYBRID - EPRI 1989
SOLAR THERMAL	PARABOLIC TROUGH SOLAR HYBRID (80MW)
SOLAR THERMAL	PARABOLIC TROUGH SOLAR HYBRID (200MW)
SOLAR THERMAL	PARABOLIC TROUGH SOLAR HYBRID (200MW) - 1998
SOLAR THERMAL	PARABOLIC TROUGH SOLAR HYBRID (80MW) - 1998
SOLAR THERMAL	TROUGH/GAS HYBRID - EPRI 1993
SOLAR THERMAL	SOLAR CENTRAL RECEIVER (100MW) - 1999, INTERMEDIATE UNIT
SOLAR THERMAL	SOLAR CENTRAL RECEIVER (100MW) - 2002, BASELOAD UNIT
SOLAR THERMAL	SOLAR CENTRAL RECEIVER (200MW) - 2004, INTERMEDIATE UNIT
SOLAR THERMAL	SOLAR CENTRAL RECEIVER (200MW) - 2006, BASELOAD UNIT
SOLAR THERMAL	SOLAR CENTRAL RECEIVER - FUTURE (200MW) - 2006, INTERMEDIATE UNIT
SOLAR THERMAL	SOLAR CENTRAL RECEIVER - FUTURE (200MW) - 2006, BASELOAD UNIT
SOLAR THERMAL	DISH/DISTRIBUTED APPLICATION
SOLAR THERMAL	HYBRID DISH/STIRLING FOR CENTRAL GENERATION - 1997
SOLAR THERMAL	PARABOLIC TROUGH - ASES
SOLAR THERMAL	PARABOLIC TROUGH - ASES 2000
WIND	NREL BASELINE WIND TURBINE
WIND	NREL CONCEPT 1 - VARIABLE SPEED TURBINE (1995)
WIND	NREL CONCEPT 2 - STALL CONTROLLED TURBINE (1995)
WIND	WIND TURBINES - HIGH PRODUCTION VOLUME
WIND	UTILITY WINDFARM, ASES
WIND	WINDFARM VARIABLE SPEED TURBINES, MINN. POWER
WIND	WINDFARM TURBINE - EPRI BASE CASE (50MW)
WIND	WINDFARM TURBINE - EPRI BASE CASE (10MW)
WIND	WINDFARM TURBINE - EPRI BASE CASE (25MW)
WIND	WINDFARM TURBINE - EPRI BASE CASE (100MW)
WIND	WINDFARM TURBINE - EPRI BASE CASE (200MW)
WIND	WINDFARM TURBINE - EPRI 2000 (50MW)
WIND	WINDFARM TURBINE - EPRI 2005 (50MW)
WIND	WINDFARM, CALIFORNIA ENERGY COMMISSION
WIND	UTILITY WINDFARM, ASES

Sensitivity to Key Assumptions

DISCOUNT RATE SENSITIVITY

In this analysis, the discount rate represents the time value of money as it relates to the expected real rate of return on an investment. All of the levelized cost projections presented in this study are sensitive to the discount rate. RDI does not propose a single rate to serve as the one true discount rate value, but rather illustrates the relationship depending on several assumed values under high, base, and low discount rate scenarios. This study uses 6% as the base case, which is the value recommended by EPRI's TAG, 9% for the high case and 3% for the low case. The base case results are presented in Section IV of this study, while the results of the high case and low case are presented below.

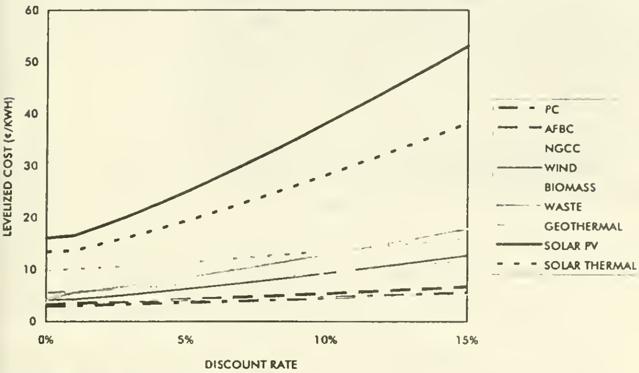
LOW DISCOUNT RATE (3%)

	PULVERIZED COAL	AFBC COAL	GAS CC	WIND CLASS 4	BIOMASS	WASTE	GEOTHERMAL	SOLAR PV	SOLAR THERMAL
(IN 1993 DOLLARS)									
CAPITAL COSTS									
TOTAL PLANT COST ($/KW)	956	1,252	572	1,195	3,060	4,379	2,400	3,741	3,147
CONSTRUCTION PERIOD (YEARS)									
FUEL PRICES									
AVERAGE DELIVERED FUEL PRICE ($/MMBTU)	1.16	1.16	3.61	0.00	3.48	(0.50)	0.00	0.00	0.00
O&M COSTS									
VARIABLE O&M (¢/KWH)	0.23	0.34	0.04	0.56	0.91	1.43	3.50	0.00	0.00
FIXED O&M ($/KW-YR)	43.48	53.97	37.00	0.00	95.13	136.91	28.47	5.99	65.44
LEVELIZED COSTS									
LEVELIZED FIXED CHARGE ($/KW-YR)	99.28	109.23	59.40	118.44	313.82	568.27	247.97	370.89	311.93
LEVELIZED O&M COSTS ($/KW-YR)	57.49	54.65	29.40	34.17	146.90	218.36	227.76	5.99	65.44
LEVELIZED FUEL COSTS ($/KW-YR)	77.10	72.30	143.40	0.00	298.01	(342.86)	0.00	0.00	0.00
CAPACITY FACTOR	80%	70%	65%	29%	70%	70%	90%	31%	26%
LEVELIZED COST OF ENERGY (¢/KWH)	**3.3**	**3.9**	**4.1**	**5.2**	**10.7**	**6.9**	**6.4**	**20.5**	**16.3**
CHANGE FROM BASE CASE	**(0.5)**	**(0.6)**	**(0.2)**	**(1.6)**	**(1.1)**	**(2.4)**	**(1.2)**	**(6.9)**	**(4.6)**

HIGH DISCOUNT RATE (9%)

	PULVERIZED COAL	AFBC COAL	GAS CC	WIND CLASS 4	BIOMASS	WASTE	GEOTHERMAL	SOLAR PV	SOLAR THERMAL
(IN 1993 DOLLARS)									
CAPITAL COSTS									
TOTAL PLANT COST ($/KW)	956	1,252	572	1,195	2,060	4,379	3,400	3,741	3,147
CONSTRUCTION PERIOD (YEARS)									
FUEL PRICES									
AVERAGE DELIVERED FUEL PRICE ($/MMBTU)	1.16	1.16	3.61	0.00	3.48	(0.50)	0.00	0.00	0.00
O&M COSTS									
VARIABLE O&M (¢/KWH)	0.23	0.34	0.04	0.56	0.91	1.43	3.50	0.00	0.00
FIXED O&M ($/KW-YR)	43.48	53.97	37.00	0.00	95.13	136.91	30.47	5.99	65.44
LEVELIZED COSTS									
LEVELIZED FIXED CHARGE ($/KW-YR)	172.48	189.95	103.31	205.72	370.20	874.78	431.35	644.16	541.77
LEVELIZED O&M COSTS ($/KW-YR)	57.48	54.65	29.40	34.17	146.90	218.36	227.76	5.99	65.44
LEVELIZED FUEL COSTS ($/KW-YR)	76.75	72.37	125.41	0.00	287.15	(342.86)	0.00	0.00	0.00
CAPACITY FACTOR	80%	70%	65%	29%	70%	70%	90%	31%	26%
LEVELIZED COST OF ENERGY (¢/KWH)	**4.4**	**5.2**	**4.5**	**8.7**	**13.1**	**11.9**	**8.9**	**35.4**	**26.3**
CHANGE FROM BASE CASE	**0.6**	**0.7**	**0.3**	**1.8**	**1.3**	**2.6**	**1.3**	**7.9**	**5.3**

SENSITIVITY OF VARIOUS TECHNOLOGIES TO DISCOUNT RATE ASSUMPTIONS



TAXES AND TAX INCENTIVES

Publicly-owned companies and cooperatives usually pay no income taxes because they are operated as non-profit entities, and this has a corresponding effect on their fixed charge rate. In addition, public power companies are often exempt from local property taxes. The table below provides RDI's levelized cost model results when the fixed charge rate has been adjusted for new tax rates and the absence of tax incentives (since no taxes are paid in the first place). Overall, the levelized costs fall appreciably, although the relative costs between technologies are not significantly changed.

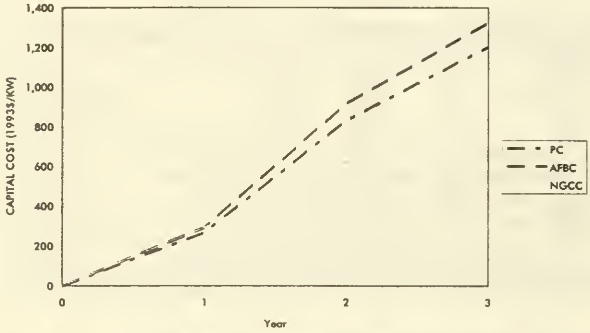
PUBLIC POWER

	PULVERIZED COAL	AFBC COAL	GAS CC	WIND CLASS 4	BIOMASS	WASTE	GEOTHERMAL	SOLAR PV	SOLAR THERMAL
(IN 1992 DOLLARS)									
CAPITAL COSTS									
TOTAL PLANT COST ($/KW)	956	1,052	572	1,195	2,060	4,379	2,400	3,741	3,147
CONSTRUCTION PERIOD (YEARS)									
FUEL PRICES									
AVERAGE DELIVERED FUEL PRICE ($/MMBTU)	1.16	1.16	2.61	0.00	3.46	(3.50)	0.00	0.00	0.00
O&M COSTS									
VARIABLE O&M (¢/KWH)	0.23	0.34	0.04	0.56	0.91	1.43	3.50	0.00	0.00
FIXED O&M ($/KW-YR)	43.48	33.97	27.08	0.00	95.12	136.91	28.47	5.99	65.44
LEVELIZED COSTS									
LEVELIZED FIXED CHARGE ($/KW-YR)	74.26	81.69	44.43	92.78	159.94	403.48	186.36	290.52	244.34
LEVELIZED O&M COSTS ($/KW-YR)	57.48	54.65	29.40	24.17	146.90	218.36	227.76	5.99	65.44
LEVELIZED FUEL COSTS ($/KW-YR)	76.90	73.12	133.52	0.00	292.12	-362.06	0.00	0.00	0.00
CAPACITY FACTOR	80%	70%	65%	29%	70%	70%	90%	21%	26%
LEVELIZED COST OF ENERGY (¢/KWH)	3.0	3.4	3.6	4.2	9.8	4.2	5.6	16.1	13.4
CHANGE FROM BASE CASE	(0.8)	(1.1)	(0.6)	(2.6)	(2.1)	(5.0)	(2.0)	(11.3)	(7.6)

CONSTRUCTION PERIODS

To examine the sensitivity of the levelized cost analyses to the assumption of overnight plant costs, the levelized cost model was adjusted to include a 12% cost of funds during construction. Construction periods selected for each technology are those considered "ideal construction times" by EPRI's TAG. Given current industry experience, however, it is possible that the construction period for gas and coal could be appreciably shortened from the estimates here. For example, while the EPRI TAG indicates a three-year period for coal, industry experience has shown that plants can reach commercial operation in as little as eighteen months. Nevertheless, given the assumption of three years, costs are distributed one-quarter in each of the first and third years, and one-half in the second year, as shown in the graph below.

COSTS DURING CONSTRUCTION



COST OF CONSTRUCTION CASE	PULVERIZED COAL	AFBC COAL	GAS CC	WIND CLASS 4	BIOMASS	WASTE	GEOTHERMAL	SOLAR PV	SOLAR THERMAL
(IN 1993 DOLLARS)									
CAPITAL COSTS									
TOTAL PLANT COST ($/KW)	1,204	1,324	679	1,226	2,445	5,199	3,849	4,190	3,534
CONSTRUCTION PERIOD (YEARS)	3	3	2	1	2	2	2	1	1
FUEL PRICES									
AVERAGE DELIVERED FUEL PRICE ($/MMBTU)	1.16	1.16	3.61	0.00	3.41	(3.50)	0.00	0.00	0.00
O&M COSTS									
VARIABLE O&M (¢/KWH)	0.23	0.34	0.04	0.56	0.91	1.43	3.50	0.00	0.00
FIXED O&M ($/KW-YR)	43.48	23.97	27.08	0.00	95.12	134.91	28.47	5.99	65.44
LEVELIZED COSTS									
LEVELIZED FIXED CHARGE ($/KW-YR)	168.04	184.85	94.84	178.18	339.82	846.19	395.95	537.95	469.26
LEVELIZED O&M COSTS ($/KW-YR)	57.48	54.45	29.40	34.37	146.90	218.36	227.76	5.99	65.44
LEVELIZED FUEL COSTS ($/KW-YR)	76.90	73.12	133.52	0.00	380.11	(362.06)	0.00	0.00	0.00
CAPACITY FACTOR	80%	70%	65%	29%	70%	70%	90%	21%	26%
LEVELIZED COST OF ENERGY (¢/KWH)	**4.3**	**5.1**	**4.5**	**7.6**	**12.5**	**11.5**	**8.4**	**30.7**	**23.2**
CHANGE FROM BASE CASE	**0.5**	**0.6**	**0.3**	**0.8**	**0.7**	**2.2**	**0.8**	**3.3**	**2.2**

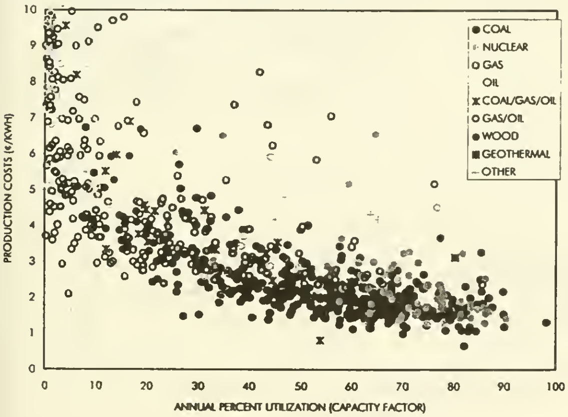
CAPACITY FACTORS

The levelized cost estimates are sensitive to the amount that a plant will be used during its service life. Therefore, various capacity factor assumptions will yield various levelized cost results. The graphs on the opposite page illustrate the sensitivity of the costs with respect to a range of capacity factors. The points of intersection on the graphs are the points at which the technologies have the same levelized costs and the same generation rates.

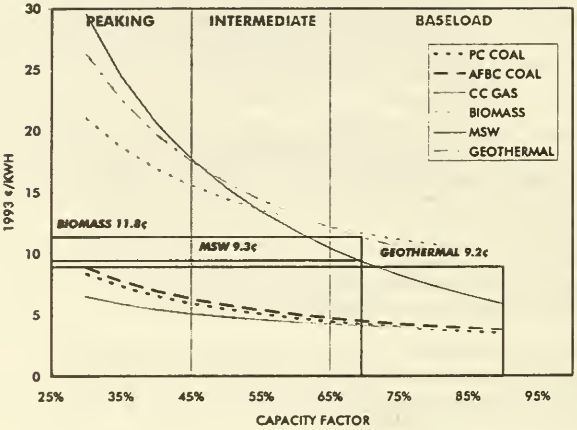
The second figure is an enlargement of the first figure, focusing on coal and natural gas technologies. This figure clearly demonstrates that coal technologies provide the least cost generation in baseload dispatch positions. Conversely, natural gas combined cycle units provide the least cost generation in intermediate and peaking dispatch positions. This follows given the higher capital and lower operating costs of coal and the lower capital and higher operating costs of natural gas. It also follows given the operating natures of natural gas and coal technologies - - natural gas generation can be increased or decreased almost on command, while coal requires hours to significantly increase or decrease generation (not withstanding certain coal-slurry peaking technologies).

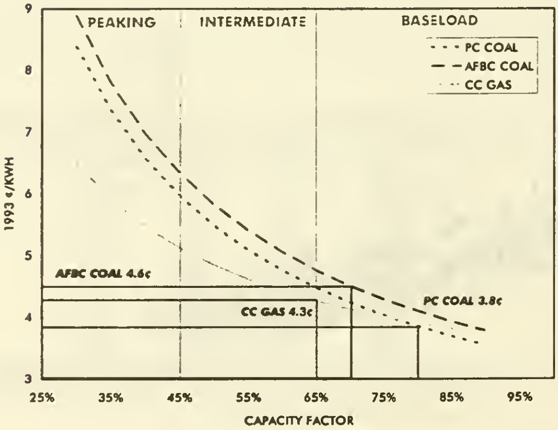
As further evidence that coal plants form the core of baseload dispatch, and as such have the lowest costs and highest capacity factors, the following figure is presented to depict the actual dispatch of U.S. utility plants in 1993. Hydro is excluded due to its seasonality, as are all plants with costs in excess of 10¢ per kilowatt hour.

U.S. UTILITY POWER PLANT DISPATCH POSITIONS, 1993
BY FUEL (AND EXCLUDING ALL PLANTS ABOVE 10¢/KWH)



SENSITIVITY OF LEVELIZED COSTS TO CAPACITY FACTOR ASSUMPTIONS





Fuel Prices

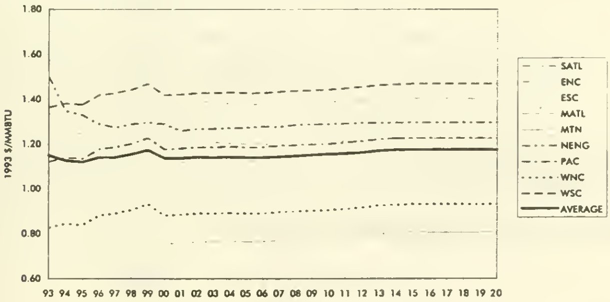
RDI'S COAL AND NATURAL GAS PRICE FORECASTS

COAL: RDI's 1995 *Outlook for Coal and Competing Fuels (Outlook)* provided F.O.B. forecast prices to 2015 in 1993 dollars. Delivered prices are estimated using constant freight charges estimated from actual 1993 coal shipments. The *Outlook* provides prices disaggregated by coal supply region, heat and sulfur content by weight. To most accurately capture the regional differences in coal prices and quality a single coal type for each demand region is used for this analysis. The coal chosen reflects the most likely fuel choice for a *new* plant in the region. For example, it is very unlikely that a new pulverized coal unit with a flue gas desulfurization (FGD) unit in Pennsylvania would choose to burn a very low sulfur subbituminous coal from the Powder River Basin because: 1) transporting the coal from the Powder River Basin is too expensive, and 2) using the FGD unit allows the plant to burn less expensive, higher sulfur coal. The table below indicates the types of coal chosen in this analysis. Because the forecast extends only to 2015, coal prices beyond the forecast period are considered flat.

COAL DEMAND REGIONS, SUPPLY REGIONS, AND QUALITIES

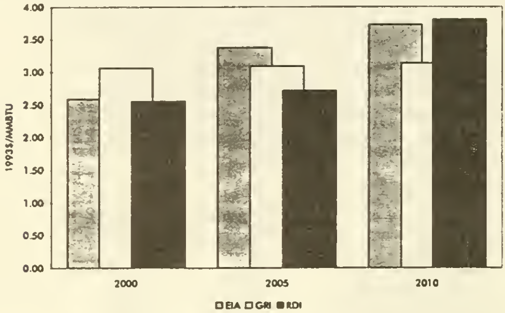
COAL DEMAND REGION	COAL SUPPLY REGION	HEAT CONTENT (BTU/LB)	SULFUR CONTENT (LBS/MMBTU)
SOUTH ATLANTIC (SATL)	CENTRAL APPALACHIA (CAPP)	≥12,500	≥2.5
EAST NORTH CENTRAL (ENC)	POWDER RIVER BASIN (PRB)	<8,800	<1.2
EAST SOUTH CENTRAL (ESC)	POWDER RIVER BASIN (PRB)	<8,800	<1.2
MIDDLE ATLANTIC (MATL)	NORTHERN APPALACHIA (NAPP)	≥12,750	≥2.5
MOUNTAIN (MTN)	POWDER RIVER BASIN (PRB)	<8,800	<1.2
NEW ENGLAND (NENG)	NORTHERN APPALACHIA (NAPP)	≥12,750	>2.5
PACIFIC (PAC)	POWDER RIVER BASIN (PRB)	<8,800	<1.2
WEST NORTH CENTRAL (WNC)	POWDER RIVER BASIN (PRB)	<8,800	<1.2
WEST SOUTH CENTRAL (WSC)	POWDER RIVER BASIN (PRB)	<8,800	<1.2

REGIONAL DELIVERED UTILITY COAL PRICE FORECAST

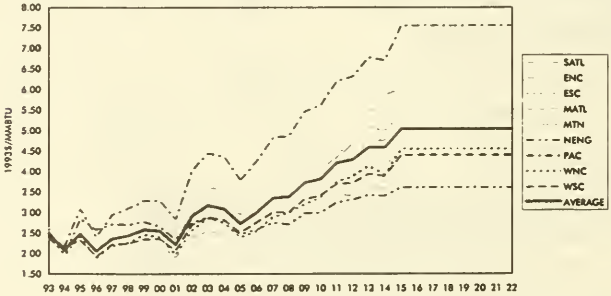


NATURAL GAS: Forecasts for delivered gas prices are also obtained from RDI's *Outlook* by demand region. Again, prices are held flat beyond the end of the forecast period in 2015. The figures below illustrate RDI's natural gas forecast compared to forecasts by the Gas Research Institute (GRI) and by the Energy Information Administration (EIA) in its *1995 Annual Energy Outlook*. A figure is also provided to compare the coal and gas forecasts.

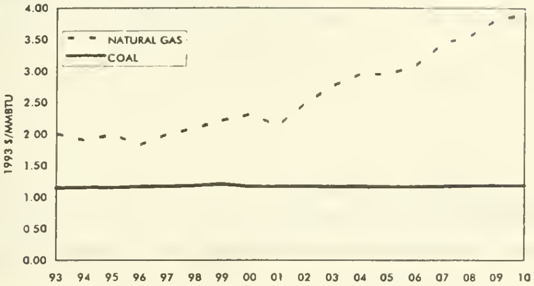
COMPARISON OF NATURAL GAS PRICE FORECASTS: RDI, GRI, AND EIA



REGIONAL DELIVERED UTILITY NATURAL GAS PRICE FORECAST



NATURAL GAS AND COAL PRICE FORECASTS



BIOMASS FUEL: Biomass fuel is currently assumed to be $3.00/mmBtu, with a real rate of escalation of 1% annually. Variation in biomass prices may be dramatic within a region or at a specific site over time. Prices of biomass fuel supply depend on location and whether the fuel is a dedicated energy crop or a biomass waste. Minnesota Power found in a June 1994 renewables study that dedicated energy crop prices may be as much as 300% of the prices for waste fuel. Currently, no biomass facility qualifies under EPAct as a dedicated energy crop facility. To cover the wide range of prices, the same biomass technology has been analyzed with fuel costs of $1.00/mmBtu and $3.00/mmBtu.

BIOMASS FUEL PRICE IN $/MMBTU	% CHANGE FROM BASE CASE	LEVELIZED COST IN ¢/KWH	NO PRICE ESCALATION-LEVELIZED COST IN ¢/KWH
1.00	(66%)	8.7	8.5
3.00	0%	11.8	11.3
6.00	100%	16.6	15.6

MUNICIPAL SOLID WASTE (MSW) TIPPING FEES: Tipping fees are currently assumed to be $35/ton, with a MSW fuelstock heat content of 5,000 Btu/lb. Like prices for wood waste, MSW tipping fees vary greatly by region and with distance from the site. Recently, some peculiar activity in this area has been noted. Because of the lower than expected cost of landfilling, many MSW plants have lowered tipping fees to attract waste. This has caused tipping fees to be higher for some local communities than for distant cities. Because of these local and regional variations, the estimate here is intended to cover the range of potential costs.

MSW TIPPING FEE IN $/TON	% CHANGE FROM BASE CASE	LEVELIZED COST ESTIMATE IN ¢/KWH
$17.50	(50%)	12.2
$35.00	0%	9.3
$52.50	50%	6.3

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ERRATA

Page	Comments
Executive Summary 7	Under the description of geothermal technologies, the last sentence in the second paragraph should read as follows: "Of the 2,700 megawatts of U.S. operating capacity, 90% are located in California."

APPENDIX 3—

Prehearing Questions And Answers For The Record

The Honorable Christine A. Ervin
Assistant Secretary for Energy Efficiency and Renewable Energy
U.S. Department of Energy

Answers to Prehearing Questions

Prehearing Questions for April 17, 1996, Hearing of the Subcommittee on Energy and Environment, Committee on Science, U.S. House of Representatives, on the Department of Energy's Fiscal Year 1997 Budget Request for the Office of Energy Efficiency and Renewable Energy Submitted to The Honorable Christine A. Ervin, Assistant Secretary for Energy Efficiency and Renewable Energy

Office of Energy Efficiency and Renewable Energy Overview

Q1. On page 459 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 249 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "In 1995, an independent commission headed by energy expert Daniel Yergin confirmed that two dozen energy efficient technologies developed with DOE funds are now 'generating billions of dollars worth of annual consumer energy savings and new business opportunities, and playing an important role in job creation.'"

Q1a. Please explain why the Secretary of Energy Advisory Board (SEAB) Task Force on Energy Research and Development, chaired by Daniel Yergin, was a "commission."

A1a. The Yergin Task Force was independently chartered by the Secretary of Energy Advisory Board (itself an independent external group) to review our civilian energy research and development program. It was a group charged to complete a specific task and therefore a "Task Force". This group has also been referred to as a Commission, but there is no intended distinction here.

Q1b. Please provide the exact citation (page number and paragraph) in the *Final Report Task Force Report on Strategic Energy Research and Development* of the quote that two dozen energy efficient technologies developed with DOE funds are now "generating billions of dollars worth of annual consumer energy savings and new business opportunities, and playing an important role in job creation."

A1b. The above quote did not appear in the Final Report of the Yergin Commission. It appeared in a letter of transmittal to Robert Hanfling, Chairman, Secretary of Energy Advisory Board, from Daniel Yergin, Chairman, Maxine Savitz, Vice Chair, and Mason Willrich, Vice Chair of the Yergin Commission.

Q2. On page 459 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 249 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "This EERE budget presents a portfolio of research activities directed at strategic national needs that will cost the public just under $1 billion this year -- but it not only addresses strategic national needs -- by the turn of the century it will have returned to the public every dollar spent and $4 billion more in energy costs savings alone."

Q2a. Please define those "strategic national needs."

A2a. The strategic national needs addressed by the DOE energy efficiency and renewable energy programs include improving national energy security, improving national environmental quality through pollution prevention, improving the productivity of energy use, and fostering national leadership in science and technology development.

Q2b. Please provide detailed documentation, including assumptions, that supports the claim that "by the turn of the century it will have returned to the public every dollar spent and $4 billion more in energy costs savings alone."

A2b. In 1994, the Office of Energy Efficiency and Renewable Energy initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts of the Office's programs in terms of impacts on energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups; review of specific technologies or groups of technologies by over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

The energy savings estimate from EE programs was derived from the Quality Metrics process. It is the product of estimated energy savings by fuel (relative to the use of conventional technologies) and EIA forecasted energy prices. These estimated savings total $10.6 billion in 2000–$4.5 billion in buildings, $2.8 billion in industry, $2.2 billion in transportation, $0.8 billion in utilities and $0.4 in FEMP. If one assumes that program expenditures total $5 billion between FY 1996 and FY 2000, the net return in terms of energy cost savings to consumers and businesses is roughly $5 billion–a return of "every dollar spent and $4 billion more in energy costs savings." Returns after 2000 are estimated to increase dramatically as capital stock continues to turn over and is replaced with much more energy efficient equipment.

Q2c. Please provide specific evidence that these energy cost savings would not occur without the DOE funding.

A2c. It is difficult analytically to apportion savings between public and private efforts. However, EERE uses a test in designing programs that ascertains the need for a government role before embarking upon any program. We only fund a technology if:

- the private sector can't do it by itself;
- there is a high social rate of return; and
- there is a strategic need of the country.

Because we use this test at the front end, the large majority of benefits resulting from EERE programs would either not occur or be substantially delayed without DOE funding. In either case, the result would be substantial losses to the American people in terms of energy savings, pollution, competitiveness and jobs.

Q3. On page 460 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 250 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "In 1997, the Office of Energy Efficiency and Renewable Energy plans over 225 R&D projects in various stages of the research pipeline. This year we expect to work with 940 major partners including consortia, laboratories, industry groups, states and retailers that will conduct R&D and help deploy EE/RE technologies to thousands of sites and users including foreign countries, 50 clean cities, all 50 states, 800 utilities, 1000 industrial partners and thousands of buildings and demonstration fleet vehicles."

Q3a. Please list those more than 225 R&D projects, including a brief description of each, the performer(s) and the DOE funding of each of these projects for the period FY 1994-FY 1997.

A3a. The current list of specific R&D projects are below.

Photovoltaic Systems R&D
1. Single crystal silicon
2. Thin-film technologies
3. Flat plat modules
4. Concentrators (high-efficiency Gallium Arsenide cells)
5. Photovoltaics

WindEnergy R&D
6. Utility-scale horizontal axis wind turbine

Geothermal Energy R&D
7. Flashed Steam Electricity
8. Binary Electricity
9. Hot Dry Rock
10. Geothermal Heat Pumps

Biomass Power R&D
11. Cofiring
12. Advanced Direct Combustion
13. Gasification
14. Direct-fired (1997-2005)/Gasification (2006-2020)

High Temperature Superconductivity R&D
15. HTS Transmission Cables
16. HTS Transformers
17. HTS Generators

Solar Thermal Electric R&D
18. Power Towers
19. Dish/Engine Systems
20. Parabolic Troughs
21. Solar Thermal Electric

Energy Storage R&D
22. Utility Battery Systems
23. Superconducting Magnetic Energy Storage
24. Flywheel Energy Storage
25. Supercapacitors
26. Advanced Power Electronics
27. Utility Energy Storage Controls
28. "Battery/Renewables (PV, wind) hybrids"

Hydrogen Research R&D
29. Thermochemical Production
30. Photochemical Production
31. Electrochemical Production
32. Physical Storage
33. Solid-State Storage
34. Hybrid Electric Vehicle
35. Internal Combustion Engine
36. Hydrogen Fuel Cells

Electric & Magnetic Fields R&D
37. Utility Industry
38. Appliance Industry
39. General Public
40. Utility Industry
41. Appliance Industry
42. General Public

Motor Challenge
43. Small Motor Horsepower Applications (below 50 HP)
44. Medium Motor Horsepower Applications (50 to 125 HP)
45. Large Motor Horsepower Applications (above 125 HP)

NICE-3
46. Alternative Aircraft De-icing Method
47. Paper Mill Optimization–Closed Loop
48. Atmospheric Recovery and Regeneration in Heat Treating
49. Brine Reuse Project
50. Ultraviolet Curing of Fiberglass Sleeving
51. Fuel-Based Nitrogen Generator
52. Reprocessing Uncured Rubber Demonstration
53. Pallet Manufacturing Using Thermoplastic/Cellulose Composite
54. Sulfur Trioxide Cleaning Process

NICE-3 (Continued)
55. Innovative Blanching Technology
56. Ink Jet Supply and Printer Solvent Recovery
57. Use of Recovered Plastics
58. Innovative Brick Kiln Design
59. Closed Cycle Kraft Pulp
60. Membrane Filteration Technology
61. Finishing Using Cathodic Arc Deposition
62. Direct Copper Plating
63. UV-Curable Coatings for Aluminum Cans
64. Full Body Powder Antichip Project
65. Nickel Plating Solutions
66. Automated Dyebath Reuse in Carpet Manufacturing
67. Advanced Mineral Calciner for Lime Regeneration
68. Water-Washed Overspray Paint
69. Electrophotographic Screening
70. Manufacture of Tissue Paper with High Content
71. Solid State RF Power Source for Electric Lighting
72. 40% Recycled Paper
73. Bioconversion of Low Value Molasses
74. Ultrasonic Tank Cleaning
75. Electric Tundish
76. Aluminum Recycling: Automobile Wheels
77. Real-Time Neural Networks
78. Dense Fluid Extraction Product Cleaning
79. Wastewater Recycle/Reuse
80. HCi Acid Recovery System
81. Cullet Feedstock Purification
82. Direct Osmosis Concentration
83. Methanol Recovery
84. Volatile Organic Compounds Control Strategies

Climate Wise
85. Technologies for Manufacturing Industries

Co-Generation
86. Advanced Turbine System
87. High Performance Steam
88. Ceramic Retrofit Gas Turbine
89. Low NOx Retrofit

Forest & Paper Products Vision
90. Ultrasonic Sensor for Paper Stiffness
91. Removal of Waste Paper Contaminant
92. Highly Bleachable Low Lignin Content Pulp
93. Black Liquor Electrolysis
94. Black Liquor Gasifier
95. Recovery Boiler Model

Forest & Paper Products Vision (Continued)

96. Energy Performance
97. Environmental Performance
98. Recycling
99. Sensors and Control

Steel Vision

100. Steel Plant Waste Oxide Recycling
101. Advanced Process Control

Glass Vision

102. Glass Furnace Oxygen Enrichment
103. Cullet Preheater Demonstration
104. Glass Furnace Sensor
105. Oxygen Enriched Air Staging for Glass Furnaces
106. Low-NOx Natural Gas Combustion System
107. Advanced Combustion Space Modeling of Glass Melting in Glass Furnaces

Metals Casting Vision

108. Casting Distortion/Mold Filling
109. Clean Ferrous Castings
110. Dimensional Control/Fatigue Prediction in Permanent Dies
111. Clean Metal Processing
112. Expendable Pattern Casting
113. Aluminum Castings–Microstructure Performance Interactions

Chemicals Vision

114. CO-2 Dry Cleaning
115. Recovery Chlorosiline Intermediates
116. Catalytic Gasification
117. Hydrobenzoic Acid
118. Inorganic/Polyphosphazene Membranes
119. Advanced Moisture Sensor–Harvesting
120. Advanced Moisture Sensor–Processing
121. Food Waste to Lactic Acid
122. Biomass to Lactic Acid
123. Biological/Chemical Caprolactam Production
124. Electroplating Waste Minimization
125. Scrap Tire Recycling
126. Auto Shredder Residue
127. Phenolics from Wood Wastes
128. Bioprocessing Systems
129. Enzymatic (Biocatalytic) Hydration

Aluminum Vision

130. Stable Cathodes
131. Inert Anodes

Aluminum Vision (Continued)
132. Alumina Sensor Control
133. Aluminum Salt Cake
134. Alumina Calciner
135. Vertical Recycling Furnace
136. Industrial Partnerships
137. Aluminum Cell Cathodes/Inert Anodes
138. Spray Forming Aluminum
139. Neodymium Oxide Cell
140. Vertical Flotation Melter/Scrap Drier

Advanced Materials & CFCC's
141. Nickel Iron Aluminides: Steel Mill Rolls
142. Materials for Recovery Boilers
143. Diesel Engine Components
144. Chemical Vapor Infiltration–CFCC Candle Filter
145. Chemical Vapor Infiltration–Hot Gas Filters
146. Chemical Vapor Infiltration–Radiant Burner and Screen
147. Sol Gel Impregnation–Hot Gas Filters
148. DIMOX–CFCC Steam Reformer
149. DIMOX–CFCC Heat Exchanger
150. Chemical Vapor Deposition of Fiber Coatings
151. Chemical Vapor Infiltration–Gas Separation Membranes

Petroleum Refining Vision
152. Catalysts with Improved Selectivities
153. Inorganic Membranes–Methanol Market
154. "Inorganic Membranes–MTBE, Styrene and Proplyene Markets"
155. Emissions/PERF
156. Active Transport Membrane
157. High Temp Catalytic Ceramic Membrane
158. Ethanol from Refining Wastes
159. Steam Methane Reforming
160. Develop Superior Asphalt Recycling Agents

Combustion Technologies
161. Recuperators

Hybrid Vehicle R&D
162. HEV I
163. HEV II
164. Flex-fuel LDVs

Lightweight Vehicle Materials R&D
165. Aluminum Intensive Vehicle

Heavy Duty Engine R&D
166. 50% Efficient Diesel for HDVs

Alternative Fuel Vehicles R&D
167. CNG
168. LPG

Fuel Cell R&D
169. Fuel Cells

Electric Vehicle R&D
170. Electric Vehicle

Light Duty Engine R&D
17 1. Advanced Diesel LDV

Lighting and Appliance Codes & Standards
172. Refrigerators and Refrigerator-Freezers
173. Room Air Conditioners
174. Mobile Home Furnaces
175. Direct Heating Equipment
176. Gas and Oil-Fired Water Heaters
177. Kitchen Ranges and Ovens (not including Microwave)
178. Clothes Washers
179. Dishwashers
180. Central Air Conditioners
181. Central Heat Pumps
182. Gas Fired Pool Heaters
183. Freezers
184. Solar Pool Heaters
185. Gas-Fired Direct Heating Equipment
186. Fluorescent Lamp Ballasts
187. EPAct Test Procedures and Labelling

Building Codes & Standards
188. State Codes/Guidelines
189. Home Energy Rating System

Lighting & Appliance R&D
190. VHF Light Sources/Electronics (Low power S-lamp)
191. VHF Light Sources/Electronics (High power S-Lamp)
192. Fixtures/Distribution Systems (Compact Flourescent Lighting)
193. New Concepts (Halogen IR)
194. Lighting Impacts (Scotopic)
195. Electronics and Semiconductor Development (Silicon Carbide Chips)
196. Appliances
197. State Procurement
198. Volume Purchase Program

Lighting & Appliance R&D (Continued)
199. Retailers Initiative
200. E-Rated Manufactured Housing

Residential Buildings
201. Building America
202. Residential Energy Efficiency Programs

Windows & Glazing R&D
203. Electrochromic Research Windows
204. Super Windows
205. Advanced Glazing Windows

Commercial Buildings
206. Advanced Buildings for 2005
207. Rebuild America
208. Existing Buildings Energy Research Program
209. Affordable Homes for Low Income Families

Best Practices
210. Design for Best Practices: Energy Tools
211. Passive Solar
212. Indoor Air Quality
213. Information and Design Tools Technology Transfer

Space Conditioning R&D
214. Residential Absorption Heat Pump
215. Hi-Cool Heat Pump
216. Large Commercial Chiller
217. Hotel/Motel Technologies Consortium
218. HID Light Replacement
219. Consortium for Energy Efficiency Equipment
220. Advanced Commercial Laundry Equipment
221. Technology Introduction Partnerships/Space Conditioning
222. Solar Space Conditioning and Water Heating-Space Heating
223. Solar Space Conditioning and Water Heating-Water Heating
224. Solar Water Heating
225. Advanced Desiccant Technology
226. Advanced Refrigeration Systems (Advanced Electric Heat Pumps)

Materials & Structures R&D
227. Advanced Insulations
228. Retrofit Insulation for Residential Walls
229. 30/30 Roof Design & Validate Moisture Migration
230. Wall/Foundation Materials
231. Urban Heat Islands/High Reflectivity Materials

Q3b. Please list the "940 major partners including consortia, laboratories, industry groups, states and retailers that will conduct R&D and help deploy EE/RE technologies to thousands of sites and users including foreign countries, 50 clean cities, all 50 states, 800 utilities, 1000 industrial partners and thousands of buildings and demonstration fleets", including the DOE funding for each of these "major partners" for the period FY 1994-FY 1997.

A3b. A comprehensive list is not available. However, partner information is available from individual technology programs within the department.

Q4. On page 460 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 250 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that "the investment in EERE technologies will prevent millions of tons of air, water and ground pollution benefiting every person in the United States, particularly the 150 million people living in the 190 areas of the country with poor air quality."

Q4a. Please provide detailed documentation, including assumptions, that supports the claim that "the investment in EERE technologies will prevent millions of tons of air, water and ground pollution".

A4a. In 1994, the Office of Energy Efficiency and Renewable Energy initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts of the Office's programs in terms of impacts on energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups; review of specific technologies or groups of technologies by over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

The energy savings estimate from EE programs was derived from the Quality Metrics process. It is the product of estimated energy savings by fuel (relative to the use of conventional technologies) and EIA forecasted energy prices. These estimated savings total $10.6 billion in 2000–$4.5 billion in buildings, $2.8 billion in industry, $2.2 billion in transportation, $0.8 billion in utilities and $0.4 in FEMP. If one assumes that program expenditures total $5 billion between FY 1996 and FY 2000, the net return in terms of energy cost savings to consumers and businesses is roughly $5 billion–a return of "every dollar spent and $4 billion more in energy costs savings." Returns after 2000 are estimated to increase dramatically as capital stock continues to turn over and is replaced with much more energy efficient equipment.

Q4b. Please provide specific evidence that these benefits would not occur without the DOE funding.

A4b. It is difficult analytically to apportion savings between public and private efforts. However, EERE uses a test in designing programs that ascertains the need for a government role before embarking upon any program. We only fund a technology if:

- the private sector can't do it by itself;
- there is a high social rate of return; and
- there is a strategic need of the country.

Because we use this test at the front end, the large majority of benefits resulting from EERE programs would either not occur or be substantially delayed without DOE funding. In either case, the result would be substantial losses to the American people in terms of energy savings, pollution, competitiveness and jobs.

On page 461 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 257 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The federal government should consider funding a technology if:

- **there is a high social rate of return;**
- **it fulfills a strategic national need; and,**
- **the private sector cannot develop it alone."**

Q5a. Please define what is a "high social rate of return".

A5a. A high social rate of return refers to a significant return that contributes to the common defense and general welfare of the United States. High is not being used in a quantitative sense; rather, it is being used to refer to public investments that are a legitimate use of tax payer dollars. For example, let's assume that the automotive industry develops a technology that increases fuel efficiency by 300 percent. The deployment of these high fuel efficiency automobiles reduces urban air emissions, thereby providing a social benefit, in terms of improved health conditions, that is not captured by the automobile industry as a financial return on its investment. Investing U.S. tax dollars in programs that reduce urban air pollution would have a high social rate of return because it contributes to the general welfare of the United States by reducing health problems and health costs, in addition to improving the quality of life and the quality of the environment.

Q5b. Please define how to determine when "the private sector cannot develop it alone".

A5b. There are a number of factors that affect the private sectors ability and willingness to invest in critical technologies:

- Inability to capture benefits from investments due to difficulties in protecting intellectual property rights.
- Accelerating of investing in R&D because of increasingly complex technologies holds and there are many feedbacks that are required to develop a successful technology.
- Increasing international competition in R&D.
- Scarcity of capital for R&D investment in some industries (e.g., most renewable technologies).

Q6. On page 462 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 251 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that "U.S. oil imports are at record levels, are continuing to grow, and could to [sic] reach nearly 60 percent by 2005. Oil imports that high would 'contribute' nearly $90 billion to the trade deficit and, according to a Department of Commerce analysis earlier this year, constitute a threat to U.S. economic security. Persian Gulf countries are projected to control 70 percent of the global market for oil by 2010–making world oil markets increasingly unstable."

Please provide detailed documentation, including assumptions, that supports these oil import and trade deficit claims, as well as the Department of Commerce analysis that such oil imports and trade deficits "constitute a threat to U.S. economic security".

A6. The projections of oil imports and trade deficit are taken from the Annual Energy Outlook 1996 published by the Energy Information Administration–the independent energy data collection and analysis agency. Net imports (crude oil and petroleum products) are projected to reach 11.4 MMBD in 2005 and 11.9 MMBD in 2010 (vs. 8.2 MMBD in 1995). At the projected prices, this would lead to oil trade deficits even higher than those cited in the Budget Request–$108 billion in 2005 and $123 billion in 2010. These levels of deficit would likely have a negative economic impact for two principal reasons. First, these funds represent productive investment capital that flows out of the U.S. economy. While some of these funds are reinvested in the U.S. economy in terms of purchase of U.S. products and companies, current data suggest that this reinvestment would be a fraction of the total trade deficit. Second, imports at this level make the U.S. potentially vulnerable to price hikes and supply disruptions–which have potential economic costs in the billions. A recent Oak Ridge National Laboratory study (Greene and Leify, 1995) estimates the total economic cost to the United States of OPEC oil price shocks and supply manipulation to be over $4 trillion cumulatively from 1972 to 1991.

Q7. On page 462 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 251 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "By the year 2000, for example, a 10% budget cut would increase U.S. energy costs by nearly $1 billion, reduce net new jobs in the economy by 7,000, increase air pollution by nearly 4 million metric tons of carbon equivalent, and add hundreds of

thousands of tons of sulfur dioxide and nitrogen oxide pollutants to the environment."

Please provide detailed documentation, including assumptions, that supports these claims.

A7. In 1994, the Office of Energy Efficiency and Renewable Energy initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts of the Office's programs in terms of impacts on as energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups, review of specific technologies or groups of technologies by over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

The detailed assumptions underlying the 10% budget cut case are essentially the same as those for the basic benefits analysis. The budget cut case was performed using an analysis tool that assessed the technical and market impact of the reduction on each planning unit. For each planning unit, appropriate assumptions are used–depending upon the nature of the technologies, how the specific markets function and how analogous technologies have fared. In some cases, the costs and performance of the technologies in a planning unit do not improve as much as expected; in others, the improvement occurs but is delayed by a certain period; in others, the delivery of a service itself is delayed. Once this analysis is done, the results are combined to produce the overall answer. As a final check, the magnitude of the budget cut is compared to the reduction in benefits for overall consistency. For example, a 10% budget cut would be very unlikely to result in a 30% drop in benefits. In the case of the analysis in question, the levels of the budget cut and the change in benefits is roughly similar, so is likely reasonable overall.

Q8. On page 463 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 252 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Technology development is the key driver of long term economic growth for our Nation."

Please document this claim.

A8. The economic literature provides both theoretical and empirical underpinnings for this understanding of the central role of technology. For example, Paul Romer, a leading contributor to this part of economic theory, puts it this way:

The most important lesson from the study of research and development, economic growth, and the history of technology is that there are more ways to arrange the objects of the physical world than humans can possibly imagine. Ultimately, all increases in standards of living can be traced to discoveries of more valuable arrangements for the things in the earth's crust and atmosphere [that is, to improvements in technology]–Romer, P.M., "Implementing a National Technology Strategy with Self-Organizing Industry Investment Boards," Brookings Papers on Economic Activity, Microeconomics, No. 2, 1993.

In another article, Romer considers trends in per capita GDP. The statistics of these trends, across a number of countries, point directly to the key role played by technology change. This article goes on to extend the theory of economic growth current at the time it was written, to include a more explicit consideration of the role of technology. In this framework and related work developed since that time, the essential role of technology development in economic growth is abundantly clear. Romer, P.M., "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, 94:5, October, 1986.

Q9. **On page 463 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 252 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "A growing body of analysis concludes that money invested in energy efficiency produces more jobs than money invested in conventional power production and in a host of other common economic activities. Newly published case studies demonstrate that energy efficiency technologies not only cut costs and save jobs for businesses, but significantly improve their productivity. Estimated annual energy cost savings resulting directly from supporting the 1997 programs are nearly $11 billion per year by the year 2000 and over $70 billion by 2010. Other cost savings in industry (increased production and reduced environmental compliance) are estimated at $20 billion by 2000 and $66 billion by 2010. Resulting job creation is expected to be 19,000 by 2000 and 180,000 by 2010."**

Q9a. **Please provide detailed documentation of each of these claims, including the peer review process undertaken.**

A9a. These estimated annual energy cost savings and job creation impacts were developed as part of the Office of Energy Efficiency and Renewable Energy's (EE) Quality Metrics (QM) effort. These estimate the potential impacts of our technologies if we meet all our goals and objectives.

Two scenarios were characterized in the integrated analysis and the simple-summation analysis: (1) a "NO-EE Case" assuming no EE programs are implemented, and (2) a "Full-EE Case" assuming all EE programs meet their objectives. The difference between these two cases is the energy savings and emission reductions attributable to the Office of Energy Efficiency and Renewable Energy. Both cases were generated with the Integrated Dynamic Energy Analysis Simulation (IDEAS) model and some parts of the National Energy Modeling System developed by EIA. The IDEAS model was calibrated to the 1995 Annual Energy Outlook's Reference Case for this analysis.

The employment estimates were generated with a model developed by Argonne National Laboratory called AMIGA and uses the inputs from the Quality Metrics exercise to estimate the potential impact on the economy and employment of the introduction of these technologies.

An external review was conducted by Arthur D. Little Inc. They reviewed the assumptions used to develop the estimates. These estimates to do not reflect their final review which was concluded on June 30, 1996.

Q9b. Please detail the funding provided by either DOE directly or indirectly through its contractors to produce these studies.

A9b. These costs are a normal part of the management and analysis for each program. In order to return the maximum benefit to our customers, benefits are assessed so that effective strategic and day-to-day management can be performed.

Q9c. Please document why these benefits would not occur in the absence of DOE funding.

A9c. It is difficult analytically to apportion savings between public and private efforts. However, EERE uses a test in designing programs that ascertains the need for a government role before embarking upon any program. We only fund a technology if:

- the private sector can't do it by itself;
- there is a high social rate of return; and
- there is a strategic need of the country.

Because we use this test at the front end, the large majority of benefits resulting from EERE programs would either not occur or be substantially delayed without DOE funding. In either case, the result would be substantial losses to the American people in terms of energy savings, pollution, competitiveness and jobs.

Q10. On page 464 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 252 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Estimated reductions in greenhouse gas emissions alone are projected to be 38 million metric tons (MMT) and over 150 MMT by 2010. Similar substantial reductions in other air emissions and waste production are projected."

Please document these claims.

A10. In 1994, the Office of Energy Efficiency and Renewable Energy initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts of the Office's programs in terms of impacts on as energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups, review of specific technologies or groups of technologies by over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

The greenhouse gas emissions reductions estimate from EE programs was derived from the Quality Metrics process. Greenhouse gas reductions are virtually all in the form of carbon dioxide. The CO2 emissions estimates are the product of estimated energy savings by fuel (relative to the use of conventional technologies) and standard conversion factors based on the carbon content of the individual fuels. These emissions reductions total 38 million metric tons (MMT) in 2000–14 MMT in buildings, 14 MMT in industry, 1 MMT in transportation, 8 MMT in utilities and 1 MMT in FEMP. Estimated emissions reductions in 2010 total over 150 MMT–58 MMT in buildings, 43 MMT in industry, 24 MMT in transportation, 24 MMT in utilities and 4 MMT in FEMP.

Q11. On page 465 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 253 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Based on the A.D. Little & Co.'s 'Third Generation' R&D portfolio analysis, the Office of Energy Efficiency and Renewable Energy has conducted an intensive analysis of all our historic programs resulting in 56 key programs comprised of our highest priority projects. Completions, efficiencies and strategic review based consolidations, scope and schedule changes, and terminations allowed us to reduce our spending while maintaining our priorities."

Q11a. Please describe the A.D. Little & Co.'s "Third Generation" R&D portfolio analysis.

A11a. Third Generation R&D links R&D with a company's overall corporate and business strategic plans, instead of managing R&D with a "hands-off" approach or justifying each R&D project individually (i.e., "How much money will the results of the project make and how soon?"). It encourages constant communication between R&D and other business functions to ensure that the right R&D is being performed to support the company's goals. In addition, Third Generation R&D looks at the whole R&D portfolio of a company, ensuring that the company has the right mix of projects that maximizes rewards and minimizes overall technical risk. High risk, but potentially high reward projects need to be balanced with low risk, but lower reward projects.

Q11b. Please explain how "the Office of Energy Efficiency and Renewable Energy has conducted an intensive analysis of all our historic programs resulting in 56 key programs comprised of our highest priority projects", and provide documentation of that analysis.

Q11c. Please document how "[c]ompletions, efficiencies and strategic review based consolidations, scope and schedule changes, and terminations allowed . . . [DOE] to reduce . . . spending while maintaining . . . priorities."

A11b&c. In 1994 EE initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts due to EE's programs on energy, economy, employment, and environment. The goal was to develop credible estimates of program benefits in terms of impacts on as energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups, review of specific technologies or groups of technologies–over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

This analysis provides benefits information to EE decision-makers that permits a better understanding of benefits and improved ability to balance a variety of benefits, costs and customer needs. Using this information helped EE decision-makers to develop a budget request that efficiently uses scarce funding to realize the DOE energy efficiency and renewable energy strategic objectives. This information also allowed EE decision-makers to emphasize the highest priority areas of the portfolio–thus providing some reductions in the cost of meeting strategic objectives.

Q12. On page 465 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on pages 253 and 254 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The department's goal is to achieve maximum leveraging from Federal funds. In one recent case, for example, $500,000 in Federal funds were used to attract nearly $33 million in state, local and private funds to DOE's Rebuild America program, an initiative that implements energy efficiency technologies in commercial and government buildings at the state and local level."

Q12a. Please provide a detailed accounting of the expenditure of the $500,000 in Federal funds.

A12a. The $500,000 will be used by the Metropolitan Energy Center (MEC) staff to form partnerships, educate owners about innovative financing options, and provide technical services to reduce building energy costs in the Kansas City, MO/KS metropolitan area. The funds will be expended over the project period. Projected expenditure of funds is as follows:

Project Director	$200K
Project Engineer	$125K
Finance Consultant	$50K
Training/building surveys	$75K
Products; financing guidelines, technical guidelines, program brochures, etc.	$30K
Expenses (office, admin support, travel, etc)	$20K

Q12b. Please provide evidence that "$33 million in state, local and private funds to DOE's Rebuild America program, an initiative that implements energy efficiency technologies in commercial and government buildings at the state and local level" would not have been attracted in the absence of the expenditure of the $500,000 in Federal funds.

A12b. The $500K allows Metropolitan Energy Center staff to facilitate cost cutting projects in buildings that have never had retrofits completed even though cost effective technologies have been available for years. MEC is focusing on non-profits, schools, hospitals, and public buildings. The $33 million leveraged by the Federal investment will not occur without Federal funding for the following reasons:

1. There is no coordination at the local level of local, state, and federal resources. For example, the state of Missouri has authority to do bond financing but no resources for marketing the service or for providing the technical assistance for project implementation. MEC is providing this coordination and assistance, and the State is a active partner.

2. The Energy Service Companies in Kansas City have had little success in penetrating the local government market because of a gap in credibility and because of contracting, and procurement barriers. For example, 15 years ago, an energy service company sold Kansas City on a contract that ended up costing the city money. Since then, they have done very little in the way of energy efficiency. MEC is providing an unbiased, objective third party to help the city contract with the private sector to obtain private financing for public energy projects. As a result, City Hall just recently completed a cost effective lighting upgrade saving thousands of dollars, and is committed to working with MEC to identify energy cost cutting measures throughout the KC municipal facilities.

3. Kansas City and other city and county governments partnering with MEC need outside financing because they do not have the capital internally, and do not want additional debt from bonds. MEC is helping these governments use performance contracting and third party financing by helping qualify vendors/contractors, helping generate bid specs, and by

providing implementation assistance. Without this type of local program these cost cutting energy efficiency projects will not be done.

4. MEC is aggregating the non-profit businesses to reduce investment costs for private financing. These small non-profits do not have the resources, nor expertise to do this on their own.

5. Utilities are working with the MEC because the Rebuild program provides an opportunity to make customers more energy efficient while expanding utility services. MEC is providing the marketing necessary to make utility capital funds more accessible.

Q13. On pages 465 and 466 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* and on page 254 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The Office of Energy Efficiency and Renewable Energy has developed a peer-reviewed 'quality metrics' system that allows DOE to set concrete goals, measure program progress, impacts and success. This evolving strategic management process, while providing valuable input to program planning and improvement, anticipates and exceeds the requirements of the Government Performance and Results Act of 1994."

Q13a. Please describe the 'quality metrics' system that allows DOE to set concrete goals, measure program progress, impacts and success".

A13a. In 1994, the Office of Energy Efficiency and Renewable Energy initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts of the Office's programs in terms of impacts on as energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups; review of specific technologies or groups of technologies by over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

Q13b. Please identify the "peers" who reviewed this "quality metrics system".

A13b. Peer reviews of the quality metrics process and results have included: process review of estimation methodologies involving many external groups, review of specific technologies or groups of technologies by over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology.

Solar and Renewable Resource Technologies

Q14. On pages 469 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Analysis of OUT benefits indicates that by 2010, 1.2 to 1.7 quads per year of primary energy will be displaced by clean manufactured renewable energy. This is equivalent to not building one hundred coal power plants of 250 MW each."

Q14a. Please define what is meant by "clean manufactured renewable energy".

A14a. The term "clean manufactured renewable energy" is meant to emphasize the characteristics of renewable energy that, with the exception of biomass power, no fuels are burned. That is, renewable energy is a technology-based ("manufactured") energy source and not a commodity-based (e.g., fossil fuel) energy source.

Q14b. Please provide documentation for the estimates of the 1.2 to 1.7 quads of primary energy that will be displaced by "clean manufactured renewable energy", by type of "clean manufactured renewable energy" (i.e., solar thermal, solar photovoltaic, wind, etc.).

A14b. Estimates of primary energy displaced for each technology are provided in the table in Section I.B. Estimate of Benefits for that technology in the FY 1997 Congressional Budget Request. The estimate of the 1.2 to 1.7 quads of primary energy result from an intensive internal effort to develop peer-review metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity which were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1994. The resulting values represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q14c. Please compare these estimates with those of the Energy Information Administration (EIA) contained in the EIA's *Annual Energy Outlook 1996*, and explain any differences.

A14c. These estimates are typically higher than those in the EIA's Annual Energy Outlook 1996. The estimates provided in the FY 1997 Congressional Budget Request allow for cost reductions in these technologies as a result of R&D advances estimating future market penetration while the EIA analyses do not.

Q14d. Please list the assumptions and calculations used to support the claim that "[t]his is equivalent to not building one hundred coal power plants of 250 MW each."

A14d. This statement was for illustrative purposes only, and is based on the estimate of approximately 25,000 MW in electric capacity additions for the renewable technologies (cumulative through the year 2010) underlying the estimate of 1.2 to 1.7 quads of primary energy displaced. The comparison is of nameplate capacity.

Q15. On page 469 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Up to 35 million metric tons of potential carbon equivalent emissions will be reduced, helping the country meet its energy needs without harming the global environment."

Please document the claim of reductions of "[u]p to 35 metric tons", including accompanying assumptions.

A15. Estimates of tons of potential carbon equivalent emissions that might be reduced by each technology are provided in the table in Section I.B. Estimate of Benefits for that technology in the FY 1997 Congressional Budget Request. The estimate of up to 35 million metric tons of potential carbon equivalent emissions reduced is derived from the cumulative sum, through the year 2010, for all of the technologies.

Q16. On page 469 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Over this period [to 2010], the export market potential for renewable energy technologies is greater than $1 trillion."

Please document this statement, and clarify whether or not the export market potential referred to above encompasses only renewable technologies or all electrical generating capacity.

A16. The estimated export market potential represents the gross export market. This assumes the International Energy Agency's forecast of the addition of 1,400,000 MW of electric capacity worldwide by the year 2010 and a $720/kW or greater average cost for the exported renewable energy technologies.

Q17. Page 470 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following performance measures for renewable energy technologies for the year 2000:

TECHNOLOGY	PERFORMANCE OBJECTIVE	COST REDUCTION GOAL
Photovoltaics	**500 megawatts installed domestically and 200 megawatts overseas.**	**10 to 15 cents per kilowatt-hour from the current level of over 20 cents.**
Solar Thermal Electric	**400 megawatts domestic and 200 megawatts overseas.**	**Less than ten cents per kilowatt-hour from approximately 17 cents (solar only mode) today.**
Wind	**3,700 megawatts domestic and 4,000 megawatts overseas.**	**2.5 cents per kilowatt-hour for good wind areas from the current**

TECHNOLOGY	PERFORMANCE OBJECTIVE	COST REDUCTION GOAL
		four to five cents.
Geothermal	500 megawatts domestic and 2,500 megawatts overseas, installed or under development. Reduce electric peak loads by 2,000 megawatts from domestic Geothermal Heat Pumps.	3.5 cents per kilowatt-hour for average grade resources compared to current 5 to 8 cents per kilowatt-hour.
Biofuels	1,200 megawatts of new electric power domestic, and 800 megawatts overseas; 600 million gallons of biomass-derived transportation fuels produced per year.	Reduce the cost of ethanol from biomass by 50 percent by the year 2010 from the current cost of $1.22 per gallon.
Solar Domestic Hot Water	Increase market penetration rate by 40 to 60 percent.	25-40 percent reduction in installed cost.

Q17a. What are the current installed domestic and overseas capacity figures for (i) photovoltaics, (ii) solar thermal electric, (iii) wind, (iv) geothermal, and (v) biofuels?

A17a(i). As of 1995, there were about 115 megawatts of installed photovoltaic capacity in the United States and about 60 megawatts overseas.

A17a(ii). Current installed solar thermal electric capacity in the United States is 354 MW. There is no overseas capacity.

A17a(iii). Approximately 1700 MW of wind capacity were installed in the United States at the end of 1995 and another 3300 MW overseas.

A17a(iv). The current geothermal electric installed capacity in the United States is 2759 MWe, which represents 40 percent of the world's total installed capacity of 6908 MWe.

A17a(v). The Energy Information Administration estimates that in 1996, there were 7,620 MW of biomass fueled capacity produced by electric utilities, nonutilities, and cogenerators in the U.S. There is no reliable data available for overseas capacity.

Q17b. What is the current installed domestic capacity and current cost for solar domestic hot water?

[Not answered.]

Q17c. Please document (i) the claim that the current cost of photovoltaic electricity is over 20 cents per kilowatt-hour, including detailed assumptions; and (ii) the current cost for reliable, standalone, 24-hour available PV electric power (i.e., includes storage, necessary redundancy, etc.).

A17c. The claimed cost of 20 cents per kWh is derived from calculations cited in a Sacramento Municipal Utility District (SMUD) report documenting the results of its 1994 procurement of residential and commercial photovoltaic systems, which was summarized in The Solar Letter (edited and published by Allan L. Frank), June 24, 1994, Vol 4, No 14, "Photovoltaic Bidder Please SMUD with lower Prices than last Year," pp. 145-6. Experience has shown that photovoltaic energy has been readily integrated into electric power systems without storage, and until photovoltaic penetration is over 10 to 15 percent, no modification to utility operation practice, nor energy storage, is necessary.

Q17d. Please document (i) the claim that the current cost of solar thermal electricity is approximately 17 cents per kilowatt-hour, including detailed assumptions; and (ii) the current cost for reliable, standalone, 24-hour available solar thermal electric power (i.e., includes storage, necessary redundancy, etc.).

A17d. The 17¢/kWh cost figure is based upon the solar component of the hybrid SEGS trough plants, which are currently operating in Southern California. The 10-MW Solar Two power tower, which began operation in January 1996, showcases the first solar thermal electricity with thermal storage capability. Based on the Solar Two design, the levelized energy cost (LEC) for a 100-MW solar-only power tower is projected to be 11¢/kWh. This assumes: 1.) 10% fixed-charge rate, 2) 30-year lifetime, 3) 4% inflation, and 4) 55% surcharge for Contingency, Project Development, etc. Dish/engine systems, with the first commercial units available in 1998/1999, are also expected to enter the market at around 11¢/kWh. However, experience has shown that solar thermal energy has been readily integrated into electric power systems without storage, and until penetration is over 10 to 15 percent, no modification to utility operation practice, nor energy storage, is necessary.

Q17e. Please document (i) the claim that the current cost of wind electricity is 4 to 5 cents per kilowatt-hour, including detailed assumptions; and (ii) the current cost for reliable, standalone, 24-hour available wind electric power (i.e., includes storage, necessary redundancy, etc.).

A17e. The current cost of wind generated electricity for utility grid-connected wind farm-type projects according to reported project bids and owners evaluation in the last two years is in the range of 4 to 5 cents per kilowatt hour. This reflects new and planned projects in California, Texas and Minnesota in good to excellent wind resources. The cost of energy depends on the wind resource, the windfarm's energy output, the capital and operations and maintenance cost of the wind turbines used, the owner's cost of financing and duration of loan, owner's desired equity return and whether the computation is in constant or nominal dollars. Experience has shown that wind energy has been readily integrated into electric power systems without storage, and until wind penetration is over 10 to 15 percent, no modification to utility operation practice, nor energy storage, is necessary.

Q17f. Please document (i) the claim that the current cost of geothermal electricity is 5 to 8 cents per kilowatt-hour, including detailed assumptions; and (ii) the

current cost for reliable, standalone, 24-hour available geothermal electric power (i.e., includes storage, necessary redundancy, etc.).

A17f. The 5 to 8 cents per kilowatt-hour cost range represents the middle of the cost spectrum for the types of geothermal resources that have been developed in the U.S. over the past several years. Within the past 18 months, California's Biennial Resource Update Plan awarded geothermal contracts for 163 MW at 5.6 cents per kWh. In Nevada, adjacent Geothermal plants at Steamboat Hills have power sales contracts for about 7.5 and 7 cents per kWh, respectively. The costs described in part (i) above are for reliable, stand-alone, 24-hour available, geothermal electric power. Existing geothermal power plants typically experience 98 percent availability rates and capacity factors over 90%, meeting or exceeding those of conventional power plants. Geothermal power plants require no energy storage or other auxiliary systems since geothermal is a base-load technology.

Solar Buildings Appliances R&D

Q18. Page 479 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "More than one million solar systems have been installed in residential and commercial buildings in the U.S. These systems currently displace more than 2600 megawatts (thermal energy equivalent) and 840 megawatts of utility peak demand."

Please document the claim that "[t]hese systems currently displace more than 2600 megawatts (thermal energy equivalent) and 840 megawatts of utility peak demand."

A18. These figures are based on an estimated 1 million systems installed through 1995 (*Solar Collector Manufacturing Activity*, Energy Information Administration, 1974-1994), and the assumption that these systems are solar water heaters (i.e. neglects space conditioning , pool heating, service hot water systems, and industrial process systems) each displacing electricity normally used to operate electric water heaters. Each system is assumed to have 60 square feet of collectors. The 2600 MW figure represents the installed capacity of these systems. This is based on a standard rating condition of 300 Btu/hr. per sq. ft. (about 1000 Watts per sq. meter) of solar insolation. Assuming an average system collection efficiency of 50%, the capacity of a system is 0.5 times 88 Watts/sq. ft. times 60 sq. ft. or approximately 2,600 Watts (9,000 Btu/hr). Since it is assumed that the electric resistance water heater would normally have supplied this 2,600 Watts, then this is the thermal energy equivalent of the electricity displaced. The installed capacity of all the systems is one million systems times 2,600 Watts per system, or 2,6W megawatts total.

The actual contribution of individual solar water heating systems towards reducing a utility's need for generating capacity during peak demand periods is a function of each utility's system characteristics, in particular which days and hours of the day peak demands occur, and the hot water use patterns (load profiles) of their residential customers in aggregate. Studies have been performed indicating that the actual impact in terms of displacing the need for peak power generating capacity varies from 200 Watts per solar water heater to about 1,400 Watts per solar water heater. For example, solar water heaters in the Sacramento Municipal Utility District (SMUD) solar water heater program were estimated to have a peak demand reduction impact of about 500 Watts per system, while a study at a

Florida utility indicated 1,400 Watts per system. A study of solar water heating impacts in Wisconsin Electric Power Company's territory estimated a 660 Watt per system reduction in peak demand. In the figures cited in the budget request, a value of 840 Watts per system was selected, which is near the midpoint of this range. If all one million water heaters are assumed to displace 840 Watts each of utility peak demand, then the total equates to one million systems time 840 Watts per system, or 840 megawatts total.

Q19. Page 480 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Solar Appliances R&D program at the proposed funding levels:

	2000	2010	2020
Total Primary Energy Displaced (Billion BTUs)	**12,000**	**27,000**	**91,000**
Total Cost Savings (Millions $ 1995)	**$90**	**$229**	**$813**
Carbon Equivalent (MM Tons)	**0.24**	**0.60**	**2.04**

Q19a. Please provide detailed documentation of these claimed benefits.

A19a. The Solar Appliances R&D energy savings are assumed to come about from the displacement of electric water heaters by active solar water heating systems. In the calculations, a set of baseline input estimates are used for all programs. The inputs have been divided into five categories: building stock, end-use loads, equipment market shares, equipment efficiencies, and replacement factors. Each of these inputs is described below, followed by a detailed description of the calculation methodology.

Building Stock

Building stock estimates are used to estimate the total energy savings at the national level for each program. Building Stock estimates are shown in Table 19.1. (*Note: All tables appear as an appendix to this question.*) The stock estimates have been developed for each of eight market segments, where the segments are characterized by building type, building vintage, and region. The stock estimates utilize the following assumptions:

- 60% of the existing building stock is in the north.
- 40% of the existing building stock is in the south.
- New stock is divided evenly across regions.
- 0.6% annual degradation rate for existing residential buildings.
- 0.5% annual degradation rate for existing commercial buildings.

Residential and Commercial existing building stock totals for the years 1990, 2000, 2005, and 2010 were provided by the Energy Information Administration's Annual Energy Outlook 1995 (AEO 1995). Total stock for the years 2015 and 2020 are extrapolated from the 2010 stock number using the growth rate for the years 2005-2010.

The model assumes that the existing stock degrades at a constant rate of 0.6% per year for residential buildings and 0.5% for commercial buildings. New stock is then calculated as the difference between the total stock as reported in AEO 1995 and the existing stock. Through the use of the assumptions listed above, the building stocks are segmented by building vintage and region. The base year is 1995, and all construction after 1995 is considered "new". Disaggregation of the building stock into "north" and "south" regions was accomplished by using the EIA climate zones published in the standard Energy Information Administration (EIA) buildings energy consumption surveys: Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS). Climate zones 1-3 (those zones with more than 4,000 heating-degree days) were designated as the "north" region, and zones 4 and 5 (those zones with less than 4,000 heating-degree days) were defined as the "south" region. Using this method, approximately 60% of the buildings are located in the north and 40% in the south. The split is assumed to remain constant throughout the analysis period, as the degradation rates are assumed to be equal across regions. It was assumed that new buildings would be split equally between the regions (50% north and 50% south) based on the pattern observed in the 1980s.

End-Use Loads

End-use load estimates are used to determine the existing water heating load per unit, in MBTU/household/year for residential buildings, and kBtu/square foot/year for commercial buildings. Table 19.9 shows the end-use loads for water heating. The end-use loads are developed from loads generated by the DOE-2 simulation model and have been developed for each market segment (building type, building vintage, and region). To separate the loads into "north" and "south" a weighted average was developed by using CBECS climate zones 1-3 for the north and 4-5 for the south.

Existing Equipment Market Shares

Equipment market shares are broken out by market segment and are estimated from CBECS, RECS, and original efforts by Pacific Northwest National Laboratory. They are shown in Table 19.2.

Equipment Efficiencies

The efficiency of equipment stock is developed from Annual Energy Outlook, 1994 (AEO, 1994) and input from program managers. Baseline equipment efficiencies are shown in Table 19.10. The assumed stock efficiency increases over time to represent existing equipment standards.

Replacement Factors

Equipment replacement factors are used in the calculation of the number of units representing the potential target market for programs targeting specific pieces of equipment. These are shown in Table 19.4. It is assumed that OBT technologies compete only with "new" units. For new buildings, all units are considered new; thus, the replacement factor for equipment in new buildings is 1.0. For existing buildings, only those units that are scheduled for replacement are considered eligible for the OBT technology. In other words, it is assumed that the OBT technology does not replace a piece of equipment unless the equipment was going to be replaced anyway. The replacement factor for existing buildings for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1998 to 2000; the factor for 2005 represents the turnover percentage from 2001 to 2005, etc.). The replacement factors are based on the specific equipment's life expectancy.

Calculation Methodology

The steps involved in calculating the energy savings associated with Solar Appliances R&D are:

- Determine size of potential market.
- Determine number of units affected by OBT program.
- Determine base water heating energy consumption.
- Determine water heating end-use loads after program implementation.
- Calculate energy savings.
- Calculate energy cost savings.
- Calculate carbon reductions.

These steps are discussed below.

Determine Size of Potential Market

Solar Appliances R&D targets electric water heaters in all buildings. The size of this potential market is calculated from the entire building stock, shown in Table 19.1, and the market share of electric water heaters in each segment, shown in Table 19.2. The product of the market share and the building stock is the equipment stock of electric water heaters, shown in Table 19.3.

The Solar Appliances R&D program assumes that solar water heaters are only installed when a new water heater is being purchased; either for new construction, or to replace an existing heater. The volume of equipment sales, shown in Table 19.5, is the product of the equipment stock and the equipment replacement factors, shown in Table 19.4. The forecast of equipment sales in Table 19.5 is the size of the potential market for solar water heaters.

Determine Number of Units Affected by OBT Program

The number of units affected by the OBT program is calculated using the program penetration rates, shown in Table 19.6, and the forecasted equipment sales (Table 19.5). The penetration rates are applied to the appropriate market segment to compute the number of installed units, shown in Table 19.7. For the new building stock, this figure represents the number of units installed within each period, and not the cumulative number. Because energy savings continue to accrue over time–a unit installed in 2000 will continue to save energy throughout its life–the number of installed units must be summed to represent the total number of installed units in the given year. The cumulative installed units are shown in Table 19.8. For example, the 2005 column in Table 19.7 shows the number of units installed in residential buildings from 2001 to 2005 (0.34 million), while the same column in Table 19.8 shows the number of units installed in residential buildings since the program was implemented (0.45 million). For the existing building stock the penetration represents the cumulative number of units in each time period, negating the need to sum the number of installed units.

Determine Base Water Heating Energy Consumption

Table 19.9 shows baseline water heating end-use loads, and Table 19.10 shows baseline equipment efficiencies. Dividing the load by the efficiency gives the baseline energy consumption, on a per building basis, shown in Table 19.11. The building level energy consumption is multiplied by the building stock to get the regional energy consumption, shown in Table 19.12.

Determine Water Heating End-Use Loads After Program Implementation

Solar water heaters save energy by reducing the water heating load that must be serviced by non-solar fuels. The performance inputs for Solar Appliances programs are defined in terms of the solar fraction, or the percent of the annual load that will be met using solar energy. The solar fractions are presented in Table 19.13.

The baseline water heating load is reduced by the solar fraction to obtain the end-use loads after project implementation, shown in Table 19.14.

Calculate Energy Savings

Dividing the end-use loads after project implementation by the baseline equipment efficiencies results in the new energy consumption, on a per building basis, shown in Table 19.15. The building level energy consumption is multiplied by the building stock to get the new regional energy consumption, shown in Table 19.16. The new regional energy consumption is subtracted from the baseline regional energy consumption to get annual energy savings, shown in Table 19.17. As electric water heaters are being displaced, these energy savings are site electricity. Table 19.18 sums the savings to get totals, and converts from site electricity to source, or primary, energy. This conversion assumes a source-to-site ratio of 3.2, which is higher than the 3.019 factor that was used for other BTS programs. The 3.2 value is accurate if it is assumed that the energy savings displace the current average mix of electricity generation technologies. The 3.019 factor is preferable if it is assumed that all new electricity generation comes from higher-efficiency fossil fuel fired plants, primarily coal and natural gas, as the EIA assumes. BTS program benefits used to be calculated using the average mix of generation sources, or 3.2, but are currently calculated using 3.019. The benefits estimates in the budget request were not updated after the change was made.

The energy savings calculations are based on performance and penetration inputs specific to the program's FY 1996 budget request, and must be adjusted to account for changes between the FY 1996 budget request and the FY 1997 budget request. Table 19.19 presents the budget requests for FY 1996 and FY 1997. The ratio of FY97 to FY96 is multiplied by the total primary energy savings to yield the total primary budget adjusted savings presented in Table 19.20.

Note that the budget used for the adjustment is actually lower than that in the final budget request. If the final FY 97 budget request had been used, the estimated energy savings would be higher. There is a discrepancy between the estimates in the budget and the actual BTS projected savings estimate for the year 2000. The estimate in the budget request should be 2 TBtu. Energy cost savings and carbon emissions estimates are also proportionally high. This results from a miscalculation in the number of installed units, and has been corrected.

Calculate Energy Cost Savings

The energy cost savings are calculated using the energy savings by fuel (Table 19.20) and projected fuel prices shown in Table 19.21. The fuel prices are applied to the corresponding energy savings by fuel (the electricity price is multiplied by the estimate of delivered electricity) to yield the consumer cost savings presented in Table 19.22.

Calculate Carbon Equivalent Emissions Reductions

The carbon reductions are calculated using the energy savings by fuel (Table 19.20) and the carbon coefficients shown in Table 19.23. The carbon coefficients are applied to the corresponding energy savings by fuel (the electricity coefficient is applied to the primary electricity estimate) to yield the carbon reductions presented in Table 19.24.

Q19b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A19b. The solar water heating industry consists of small entrepreneurial firms. The industry does not have and cannot afford the expertise needed to address the technical, economic, and market barriers that inhibit the wider acceptance of solar water heating technology. This expertise is being provided by DOE to ensure that the potential benefits of solar water heating technology are achieved. Without DOE support, technology advancement and market penetration in this area will be slowed significantly.

APPENDIX TABLES FOR QUESTION 19.a

Table 19.1 Building Stock

Building Type: Residential **Units:** Million Households

Building Vintage	**Building Region**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
New	North	0.75	1.60	2.40	4.20	4.40	4.75	4.75
New	South	0.75	1.60	2.40	4.20	4.40	4.75	4.75
New	Total	1.50	4.70	9.50	17.90	26.70	36.20	45.70
Existing	North	57.66	56.77	55.44	53.04	50.40	47.31	44.22
Existing	South	38.44	37.85	36.96	35.36	33.60	31.54	29.48
Total	Total	97.60	99.32	101.90	106.30	110.70	115.05	119.40

Building Type: Commercial **Units:** Billion Square Feet

Building Vintage	**Building Region**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
New	North	0.70	1.44	2.16	3.70	3.85	3.98	3.98
New	South	0.70	1.44	2.16	3.70	3.85	3.98	3.98
New	Total	1.40	4.28	8.60	16.00	23.70	31.65	39.60
Existing	North	40.20	39.43	38.28	35.64	32.88	30.24	27.60
Existing	South	26.80	26.29	25.52	23.76	21.92	20.16	18.40
Total	Total	68.40	70.00	72.40	75.40	78.50	82.05	85.60

Table 19.2 **Existing Equipment Market Shares:** Electric Storage Water Heaters

Building Type: Residential **Units:** % of Households

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	22%	23%	23%	23%	22%	22%	22%
New	South	22%	23%	23%	23%	22%	22%	22%
Existing	North	22%	23%	23%	23%	22%	22%	22%
Existing	South	22%	23%	23%	23%	22%	22%	22%

Building Type: Commercial **Units:** % of Square Feet

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	7%	8%	9%	11%	13%	15%	17%
New	South	7%	8%	9%	11%	13%	15%	17%
Existing	North	7%	8%	9%	11%	13%	15%	17%
Existing	South	7%	8%	9%	11%	13%	15%	17%

Table 19.3 **Equipment Stock:** Electric Storage Water Heaters

Building Type: Residential **Units:** Million households

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.17	0.36	0.55	0.95	0.97	1.06	1.06
New	South	0.17	0.36	0.55	0.95	0.97	1.06	1.06
Existing	North	12.90	12.84	12.68	12.06	11.16	10.53	9.90
Existing	South	8.60	8.56	8.46	8.04	7.44	7.02	6.60

Building Type: Commercial **Units:** Billion Square Feet

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.05	0.11	0.19	0.40	0.51	0.60	0.66
New	South	0.05	0.11	0.19	0.40	0.51	0.60	0.66
Existing	North	2.68	3.07	3.40	3.87	4.38	4.53	4.59
Existing	South	1.79	2.05	2.27	2.58	2.92	3.02	3.06

Table 19.4 **Replacement Factors**

Units: New Equipment Purchases as a % of Equipment Stock

Building Type: Residential

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	100%	100%	100%	100%	100%	100%	100%
New	South	100%	100%	100%	100%	100%	100%	100%
Existing	North	7%	14%	21%	35%	35%	35%	35%
Existing	South	7%	14%	21%	35%	35%	35%	35%

Building Type: Commercial

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	100%	100%	100%	100%	100%	100%	100%
New	South	100%	100%	100%	100%	100%	100%	100%
Existing	North	7%	14%	21%	35%	35%	35%	35%
Existing	South	7%	14%	21%	35%	35%	35%	35%

Table 19.5 **Equipment Sales:** Electric Storage Water Heaters

Building Type: Residential **Units:** Million Households

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.17	0.36	0.55	0.95	0.97	1.06	1.06
New	South	0.17	0.36	0.55	0.95	0.97	1.06	1.06
Existing	North	0.90	1.80	2.66	4.22	3.91	3.69	3.46
Existing	South	0.60	1.20	1.78	2.81	2.60	2.46	2.31

Building Type: Commercial **Units:** Billion Square Feet

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.05	0.11	0.19	0.40	0.51	0.60	0.66
New	South	0.05	0.11	0.19	0.40	0.51	0.60	0.66

Existing	North	0.19	0.43	0.71	1.36	1.53	1.59	1.61
Existing	South	0.13	0.29	0.48	0.90	1.02	1.06	1.07

Table 19.6 **Penetration Rates** **Units:** % of equipment sales in period

Building Type: Residential

Building Vintage	**Building Region**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
New	North	0%	0%	2%	4%	13%	20%	27%
New	South	0%	0%	3%	7%	20%	30%	40%
Existing	North	0%	0%	2%	3%	9%	13%	16%
Existing	South	0%	0%	2%	4%	12%	17%	23%

Building Type: Commercial

Building Vintage	**Building** Region	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
New	North	0%	0%	3%	3%	10%	11%	12%
New	South	0%	0%	3%	6%	16%	17%	18%
Existing	North	0%	0%	3%	3%	5%	6%	7%
Existing	South	0%	0%	3%	3%	9%	10%	11%

Table 19.7 **Installed Units (New in Period)**

Building Type: Residential **Units:** Million households

Building Vintage	**Building Region**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
New	North	0.00	0.00	0.01	0.04	0.13	0.21	0.29
New	South	0.00	0.00	0.02	0.06	0.20	0.32	0.42
Existing	North	0.00	0.00	0.05	0.12	0.36	0.47	0.56
Existing	South	0.00	0.00	0.03	0.12	0.30	0.43	0.54
	Total	0.00	0.00	0.10	0.34	0.98	1.43	1.81

Building Type: Commercial **Units:** Billion Square Feet

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.00	0.00	0.01	0.01	0.05	0.07	0.08
New	South	0.00	0.00	0.01	0.02	0.08	0.10	0.12
Existing	North	0.00	0.00	0.02	0.03	0.07	0.10	0.12
Existing	South	0.00	0.00	0.02	0.03	0.09	0.10	0.11
	Total	0.00	0.00	0.05	0.10	0.30	0.37	0.43

Table 19.8 **Cumulative Installed Units**

Building Type: Residential **Units:** Million households

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.00	0.00	0.01	0.05	0.18	0.39	0.68
New	South	0.00	0.00	0.02	0.08	0.27	0.59	1.01
Existing	North	0.00	0.00	0.05	0.17	0.53	0.99	1.56
Existing	South	0.00	0.00	0.03	0.15	0.45	0.88	1.42
	Total	0.00	0.00	0.10	0.45	1.43	2.85	4.67

Building Type: Commercial **Units:** Billion Square Feet

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.00	0.00	0.01	0.02	0.07	0.14	0.22
New	South	0.00	0.00	0.01	0.03	0.11	0.21	0.33
Existing	North	0.00	0.00	0.02	0.06	0.13	0.23	0.35
Existing	South	0.00	0.00	0.02	0.05	0.14	0.24	0.36
	Total	0.00	0.00	0.05	0.15	0.45	0.82	1.25

Table 19.9 **End-Use Loads:** Water Heating

Building Type: Residential **Units:** MBtu/HH/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020

New	North	12.94	12.94	12.94	12.94	12.94	12.94	12.94
New	South	12.94	12.94	12.94	12.94	12.94	12.94	12.94
Existing	North	12.94	12.94	12.94	12.94	12.94	12.94	12.94
Existing	South	12.94	12.94	12.94	12.94	12.94	12.94	12.94

Building Type: Commercial **Units:** kBtu/SF/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	2.00	2.00	2.00	2.00	2.00	2.00	2.00
New	South	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Existing	North	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Existing	South	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Table 19.10 **Existing Equipment Efficiencies:** Water Heating

Building Type: Residential

Building Vintage	Fuel Type	1995	1997	2000	2005	2010	2015	2020
New	**Electricity**	**0.89**	**0.89**	**0.89**	**0.89**	**0.91**	**0.91**	**0.91**
New	Natural Gas	0.55	0.55	0.55	0.55	0.56	0.56	0.56
New	Oil	0.55	0.55	0.55	0.55	0.56	0.56	0.56
Existing	**Electricity**	**0.84**	**0.86**	**0.87**	**0.89**	**0.91**	**0.91**	**0.91**
Existing	Natural Gas	0.52	0.53	0.54	0.55	0.56	0.56	0.56
Existing	Oil	0.49	0.51	0.53	0.55	0.56	0.56	0.56

Building Type: Commercial

Building Vintage	Fuel Type	1995	1997	2000	2005	2010	2015	2020
New	**Electricity**	**0.85**	**0.85**	**0.85**	**0.85**	**0.86**	**0.86**	**0.86**
New	Natural Gas	0.74	0.74	0.74	0.74	0.76	0.76	0.76
New	Oil	0.74	0.74	0.74	0.74	0.75	0.75	0.75
Existing	**Electricity**	**0.81**	**0.83**	**0.84**	**0.85**	**0.86**	**0.86**	**0.86**
Existing	Natural Gas	0.68	0.70	0.72	0.74	0.76	0.76	0.76
Existing	Oil	0.69	0.71	0.73	0.74	0.75	0.75	0.75

Table 19.11 **Building Level Baseline Consumption:** Water Heating

Building Type: Residential **Units:** MBtu/HH/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	14.54	14.54	14.54	14.54	14.22	14.22	14.22
New	South	14.54	14.54	14.54	14.54	14.22	14.22	14.22
Existing	North	15.40	15.13	14.87	14.54	14.22	14.22	14.22
Existing	South	15.40	15.13	14.87	14.54	14.22	14.22	14.22

Building Type: Commercial **Units:** kBtu/SF/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	2.35	2.35	2.35	2.35	2.33	2.33	2.33
New	South	2.35	2.35	2.35	2.35	2.33	2.33	2.33
Existing	North	2.47	2.42	2.38	2.35	2.33	2.33	2.33
Existing	South	2.47	2.42	2.38	2.35	2.33	2.33	2.33

Table 19.12 **Regional Baseline Consumption:** Water Heating **Units:** TBtu/Year

Building Type: Residential

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.0	0.0	0.1	0.7	2.5	5.6	9.7
New	South	0.0	0.0	0.2	1.1	3.9	8.4	14.4
Existing	North	0.0	0.0	0.7	2.5	7.5	14.1	22.1
Existing	South	0.0	0.0	0.5	2.1	6.4	12.5	20.2

Building Type: Commercial

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.0	0.0	0.0	0.0	0.2	0.3	0.5
New	South	0.0	0.0	0.0	0.1	0.3	0.5	0.8

Existing	North	0.0	0.0	0.1	0.1	0.3	0.5	0.8
Existing	South	0.0	0.0	0.0	0.1	0.3	0.6	0.8

Table 19.13 **Performance Inputs** **Units:** Solar Fraction

Building Type: Residential

Building Vintage	**Building Region**	1995	1997	2000	2005	2010	2015	2020
New	North	0%	24%	47%	50%	52%	54%	56%
New	South	0%	27%	55%	57%	60%	63%	65%
Existing	North	0%	24%	47%	50%	52%	54%	56%
Existing	South	0%	27%	55%	57%	60%	63%	65%

Building Type: Commercial

Building Vintage	**Building Region**	1995	1997	2000	2005	2010	2015	2020
New	North	0%	26%	53%	56%	59%	61%	64%
New	South	0%	31%	62%	65%	68%	71%	74%
Existing	North	0%	26%	53%	56%	59%	61%	64%
Existing	South	0%	31%	62%	65%	68%	71%	74%

Table 19.14 **End-Use Loads After Project Implementation:** Water Heating

Building Type: Residential **Units:** MBtu/HH/Year

Building Vintage	**Building Region**	1995	1997	2000	2005	2010	2015	2020
New	North	12.94	9.87	6.81	6.52	6.25	5.97	5.68
New	South	12.94	9.40	5.86	5.54	5.21	4.83	4.55
Existing	North	12.94	9.87	6.81	6.52	6.25	5.97	5.68
Existing	South	12.94	9.40	5.86	5.54	5.21	4.83	4.55

Building Type: Commercial **Units:** kBtu/SF/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	2.00	1.47	0.94	0.89	0.83	0.78	0.73
New	South	2.00	1.39	0.77	0.71	0.64	0.58	0.51
Existing	North	2.00	1.47	0.94	0.89	0.83	0.78	0.73
Existing	South	2.00	1.39	0.77	0.71	0.64	0.58	0.51

Table 19.15 **Building Level New Consumption**

Building Type: Residential **Units:** MBtu/HH/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	14.54	11.09	7.65	7.33	6.87	6.56	6.24
New	South	14.54	10.56	6.59	6.22	5.73	5.31	5.01
Existing	North	15.40	11.55	7.82	7.33	6.87	6.56	6.24
Existing	South	15.40	11.00	6.74	6.22	5.73	5.31	5.01

Building Type: Commercial **Units:** kBtu/SF/Year

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	2.35	1.73	1.11	1.05	0.96	0.91	0.85
New	South	2.35	1.63	0.91	0.83	0.75	0.67	0.60
Existing	North	2.47	1.78	1.12	1.05	0.96	0.91	0.85
Existing	South	2.47	1.68	0.92	0.83	0.75	0.67	0.60

Table 19.16 **Regional New Consumption** **Units:** TBtu/Year

Building Type: Residential

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.0	0.0	0.1	0.4	1.2	2.6	4.2
New	South	0.0	0.0	0.1	0.5	1.6	3.1	5.1
Existing	North	0.0	0.0	0.4	1.3	3.6	6.5	9.7
Existing	South	0.0	0.0	0.2	0.9	2.6	4.7	7.1

Building Type: Commercial

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.0	0.0	0.0	0.0	0.1	0.1	0.2
New	South	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Existing	North	0.0	0.0	0.0	0.1	0.1	0.2	0.3
Existing	South	0.0	0.0	0.0	0.0	0.1	0.2	0.2

Table 19.17 Actual Energy Savings Units: TBtu/Year

Building Type: Residential

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.0	0.0	0.1	0.4	1.3	3.0	5.4
New	South	0.0	0.0	0.1	0.7	2.3	5.2	9.3
Existing	North	0.0	0.0	0.3	1.2	3.9	7.6	12.4
Existing	South	0.0	0.0	0.3	1.2	3.8	7.8	13.1

Building Type: Commercial

Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
New	North	0.0	0.0	0.0	0.0	0.2	0.3	0.5
New	South	0.0	0.0	0.0	0.1	0.3	0.5	0.8
Existing	North	0.0	0.0	0.1	0.1	0.3	0.5	0.8
Existing	South	0.0	0.0	0.0	0.1	0.3	0.6	0.8

Table 19.18 Energy Savings, All Equipment Types and End-Uses Units: Tbtu/Year

Delivered Electricity

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	3	5
Residential	New	South	0	0	0	1	2	5	9
Residential	Existing	North	0	0	0	1	4	8	12

Residential	Existing	South	0	0	0	1	4	8	13
Commercial	New	North	0	0	0	0	0	0	1
Commercial	New	South	0	0	0	0	0	0	1
Commercial	Existing	North	0	0	0	0	0	1	1
Commercial	Existing	South	0	0	0	0	0	1	1
Total			0	0	1	4	12	26	43

Primary Electricity **Electricity Conversion Ratio:** 3.2

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	4	10	17
Residential	New	South	0	0	0	2	7	17	30
Residential	Existing	North	0	0	1	4	12	24	40
Residential	Existing	South	0	0	1	4	12	25	42
Commercial	New	North	0	0	0	0	1	1	2
Commercial	New	South	0	0	0	0	1	2	2
Commercial	Existing	North	0	0	0	0	1	2	3
Commercial	Existing	South	0	0	0	0	1	2	3
Total			0	0	3	12	40	82	138

Total Primary

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	4	10	17
Residential	New	South	0	0	0	2	7	17	30
Residential	Existing	North	0	0	1	4	12	24	40
Residential	Existing	South	0	0	1	4	12	25	42
Commercial	New	North	0	0	0	0	1	1	2
Commercial	New	South	0	0	0	0	1	2	2
Commercial	Existing	North	0	0	0	0	1	2	3
Commercial	Existing	South	0	0	0	0	1	2	3
Total			0	0	3	12	40	82	138

Table 19.19 **Budget Adjustment**

FY 96 Budget Request:	4.47 million $
FY 97 Budget Request:	3.137 million $

Table19.20 **Budget Adjusted Energy Savings, All Equipment Types and End-Uses** **Units:** Tbtu/Year

Delivered Electricity

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	2	4
Residential	New	South	0	0	0	0	2	4	7
Residential	Existing	North	0	0	0	1	3	5	9
Residential	Existing	South	0	0	0	1	3	5	9
Commercial	New	North	0	0	0	0	0	0	0
Commercial	New	South	0	0	0	0	0	0	1
Commercial	Existing	North	0	0	0	0	0	0	1
Commercial	Existing	South	0	0	0	0	0	0	1
Total			0	0	1	3	9	18	30

Primary Electricity **Electricity Conversion Ratio:** 3.2

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	3	7	12
Residential	New	South	0	0	0	1	5	12	21
Residential	Existing	North	0	0	1	3	9	17	28
Residential	Existing	South	0	0	1	3	9	18	29
Commercial	New	North	0	0	0	0	0	1	1
Commercial	New	South	0	0	0	0	1	1	2
Commercial	Existing	North	0	0	0	0	1	1	2
Commercial	Existing	South	0	0	0	0	1	1	2
Total			0	0	2	9	28	58	97

Total Primary

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	3	7	12
Residential	New	South	0	0	0	1	5	12	21
Residential	Existing	North	0	0	1	3	9	17	28
Residential	Existing	South	0	0	1	3	9	18	29
Commercial	New	North	0	0	0	0	0	1	1

Commercial	New	South	0	0	0	0	1	1	2
Commercial	Existing	North	0	0	0	0	1	1	2
Commercial	Existing	South	0	0	0	0	1	1	2
Total			0	0	2	9	28	58	97

Table 19.21 **Fuel Prices** **Units:** 1995 $ / MBtu

Building Type	Fuel Type	1995	1997	2000	2005	2010	2015	2020
Residential	Electricity	24.82	24.95	25.15	26.36	27.64	28.15	28.66
Residential	Natural Gas	6.46	6.45	6.44	7.16	7.48	8.16	8.89
Residential	Oil	7.07	7.46	8.06	8.55	9.05	9.57	10.13
Commercial	Electricity	22.21	22.36	22.59	23.76	24.76	25.18	25.60
Commercial	Natural Gas	5.36	5.39	5.41	6.15	6.50	7.18	7.92
Commercial	Oil	4.82	5.19	5.79	6.26	6.75	7.27	7.82

Table 19.22 **Consumer Cost Savings** **Units:** Million 1995 $

Delivered Electricity

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	1	7	26	59	109
Residential	New	South	0	0	2	12	45	104	187
Residential	Existing	North	0	0	6	23	75	151	250
Residential	Existing	South	0	0	4	20	66	138	235
Commercial	New	North	0	0	0	1	3	6	9
Commercial	New	South	0	0	0	1	5	9	14
Commercial	Existing	North	0	0	1	2	5	9	14
Commercial	Existing	South	0	0	1	2	6	10	15
Total			0	0	15	68	230	486	833

Total

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	1	7	26	59	109
Residential	New	South	0	0	2	12	45	104	187
Residential	Existing	North	0	0	6	23	75	151	250
Residential	Existing	South	0	0	4	20	66	138	235
Commercial	New	North	0	0	0	1	3	6	9

Table 19.23 **Carbon Coefficients**

Units: MM Tons / QBtu

Fuel Type	Coefficient
Electricity	22.32
Natural Gas	14.69
Oil	19.65

Table 19.24 **Carbon Equivalent Emissions Reductions** **Units:** MM Ton / Year

Primary Electricity

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.02	0.07	0.15	0.27
Residential	New	South	0.00	0.00	0.01	0.03	0.12	0.26	0.47
Residential	Existing	North	0.00	0.00	0.02	0.06	0.19	0.38	0.62
Residential	Existing	South	0.00	0.00	0.01	0.06	0.19	0.39	0.66
Commercial	New	North	0.00	0.00	0.00	0.00	0.01	0.02	0.03
Commercial	New	South	0.00	0.00	0.00	0.00	0.01	0.02	0.04
Commercial	Existing	North	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Commercial	Existing	South	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Total			0.00	0.00	0.04	0.19	0.62	1.28	2.16

Total

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.02	0.07	0.15	0.27
Residential	New	South	0.00	0.00	0.01	0.03	0.12	0.26	0.47
Residential	Existing	North	0.00	0.00	0.02	0.06	0.19	0.38	0.62
Residential	Existing	South	0.00	0.00	0.01	0.06	0.19	0.39	0.66
Commercial	New	North	0.00	0.00	0.00	0.00	0.01	0.02	0.03
Commercial	New	South	0.00	0.00	0.00	0.00	0.01	0.02	0.04

Commercial	Existing	North	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Commercial	Existing	South	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Total			0.00	0.00	0.04	0.19	0.62	1.28	2.16

Q20. Please provide a listing of the recipients of (i) the $4,349,000 in funding in FY 1995, (ii) the $1,942,000 in FY 1996 funding, and (iii) the requested level of $5,000,000 in FY 1997 for the Solar Buildings Appliances R&D program, including the funding for each recipient.

A20. The recipients of funding for the Solar Buildings Appliances R&D for FY 1995, FY 1996, and FY 1997 (request) are shown in the following table.

Solar Buildings Funding Recipients
(In Thousands of $)

MAJOR RECIPIENT	FY 95	FY 96	FY 97
National Renewable Energy Laboratory	2,040	576	TBD
University of Wisconsin	275	200	TBD
Colorado State University	200	115	TBD
FSEC	270	165	TBD
Solar Energy Industries Association (SEIA)	460	200	TBD
Solar Rating & Certification Corp. (SRCC)	305	80	TBD
Cal SEIA	70	50	TBD
Enstar	0	75	TBD
Arizona State University	50	60	TBD
University of Minnesota	50	50	TBD
University of Texas	25	25	TBD
Science Applications International Corp.	65	80	TBD
Solar Design Assoc.	90	0	TBD
Renewable Energy Consultants	50	0	TBD
American Institute of Architects	100	0	TBD
Princeton Economic Research Inc.	120	0	TBD
Arthur D. Little	40	0	TBD
Pacific Northwest Lab (PNL)	27	0	TBD
Meridian	64	0	TBD
Others (competitive, TBD)	48	266	TBD
TOTAL	**4,349**	**1,942**	**TBD**

Q21. For each of Solar Appliances R&D funds identified in the response to question 20 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A21. The level of cost-sharing in thousands of dollars provided by each recipient identified in the response to question 20 is provided in the following table.

Solar Buildings Funding Recipient Cost-Sharing
(In Thousands of $)

MAJOR RECIPIENT	COMPETITIVE	FY 95	FY 96	FY 97
National Renewable Energy Laboratory	Lab (No)	250*	250*	TBD
University of Wisconsin	No	100	100	TBD
Colorado State University	No	23	64	TBD
FSEC	No	60	40	TBD
Solar Energy Industries Association (SEIA)	No	60	60	TBD
Solar Rating & Certification Corp. (SRCC)	No	20	20	TBD
Cal SEIA	No	25	25	TBD
Enstar	No	0	0	TBD

MAJOR RECIPIENT	COMPETITIVE	FY 95	FY 96	FY 97
Arizona State University	No	50	302	TBD
University of Minnesota	No	50	26	TBD
University of Texas	No	0	0	TBD
Science Applications International Corp.	No	0	0	TBD
Solar Design Assoc.	No	0	0	TBD
Renewable Energy Consultants	No	0	0	TBD
American Institute of Architects	No	25	0	TBD
Princeton Economic Research Inc.	Yes	0	0	TBD
Arthur D. Little	Yes	0	0	TBD
Pacific Northwest Lab (PNL)	Lab (No)	0	0	TBD
Meridian	Yes	0	0	TBD
Others (competitive, TBD)	Yes	0	0	TBD**
TOTAL		663	887	TBD

*Industry contribution to a Federal Laboratory directed Cooperative Research and Development Agreement (CRADA).

**The level of cost sharing in FY 1997 is expected to be roughly consistent with that in FY 1995 and FY 1996.

Q22. For those Solar Buildings Appliances R&D program funding recipients listed in 20 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A22. The awards made on a non-competitive basis are identified in the table for the response to question 21, above. The justifications for those awards are provided below:

University of Wisconsin: Developed and maintains TRNSYS computer model of solar energy systems; world renowned experts in solar energy. TRNSYS is the pre-eminent solar system modeling tool for researchers and systems analysts. As the developers of the tool, the University is in the best position to maintain and upgrade it.

Colorado State University: Over the last 20 years has established perhaps the Nation's best capability for testing solar energy systems for residential solar heating and cooling applications. The location is particularly well-suited for such testing. The university and its staff are recognized experts in this area.

Florida Solar Energy Center (FSEC): Established experts in the certification and testing of solar domestic hot water systems. FSEC has maintained a first-class capability in this area dating back to the 1970's. FSEC's strategic location in a state that has one of the strongest solar manufacturing capabilities in the U.S., makes it ideally suited for this mission.

Solar Energy Industries Association (SEIA): Represents the solar domestic hot water manufacturing and installation industry. It provides valuable insights into the needs of its membership to the program, and is in a unique position to translate the results of program activities to these members.

Solar Rating and Certification Corporation (SRCC): SRCC is an independent, non-profit organization which certifies and rates the performance of solar energy equipment. As such SRCC is directly responsible for implementing the technical procedures currently under development by the Program for the rating and certification of solar equipment for the solar industry.

California Solar Energy Industries Association (CalSEIA): Mr. Les Nelson of CalSEIA is Chairman of the SEIA Solar Thermal Buildings Products Division and serves as a direct link to industry and the regional issues, barriers, and opportunities for solar implementation in California.

Enstar: Mr. Chip Bircher has extensive experience in the development of utility solar hot water programs. His knowledge of, and access to, utility decision makers is instrumental in facilitating activities under the USH_2O framework. He was a key contributor in developing the solar energy service company (ESCO) approach, and is expected to play an important role in gaining utility support for the concept.

Arizona State University: Professor Byard Wood serves as Technical Director of the Solar Ratings and Certification Corporation (SRCC) and is an acknowledged expert in systems certification issues. His strong leadership and knowledge of state and national certification institutions, provides the SRCC with a most effective resource for increasing acceptance of its certification procedures.

University of Minnesota: Professor Jane Davidson has continued her work (begun at Colorado State University) on the development of improved certification test methods. By virtue of her previous involvement in this area and her proven skills, she is extremely well-qualified to perform this work.

University of Texas: Professor Gary Vliet submitted an unsolicited proposal to NREL to perform pioneering work to address the problem of scale deposition in solar domestic hot water systems. The approach offered by the proposer, coupled with his strong qualifications, appeared to offer a good opportunity to address an important issue.

Science Applications International Corporation (SAIC): Mr. Robert Lorand has provided technology analysis and strategic planning services to NREL and the DOE solar building technology programs for over 15 years, and has been a key participant in numerous program evaluations. His understanding of the program and issues, and corporate memory provide a unique resource for the program.

Solar Design Associates: Dr. Steven Strong is considered the Nation's foremost expert in building-integrated photovoltaics (BIPV) systems. He was the architect for the country's first BIPV home and continues to be a leader in this technology. In addition, he brings insights on international developments based on his broad ranging experience in this area.

Renewable Energy Consultants (REC): Dr. Fred Morse of Renewable Energy Consultants is a former Director of the Solar Heating and Cooling Division of DOE and has extensive experience with utility applications of solar energy. He helped establish the framework for utility participation within USH_2O.

American Institute of Architects (AIA): The American Institute of Architects is the leading professional organization for architects and is the best vehicle for communicating new building energy concepts to the architectural community. They are particularly influential in advancing these concepts in the non-residential buildings market.

Photovoltaic Energy Systems

Q23. Page 486 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the DOE Photovoltaic Energy Systems program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.01 Q**	**0.03 Q**	**0.89 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$93 M**	**$224 M**	**$2,737 M**
Carbon Equivalent Emissions Reductions	**0.29 MMT**	**0.65 MMT**	**7.67 MMT**

Q23a. Please provide detailed documentation of these claimed benefits.

A23a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity from photovoltaics which were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1995. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made.

Q23b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A23b. The benefits cited are based on past and expected future technology improvements resulting from DOE support of R&D conducted by the National Laboratories and U.S. industry. The DOE supported research addresses the most critical technical and customer-acceptance issues in Photovoltaics. We cannot state with certainty that all private research efforts would cease without the Federal program, but we do know that the Federally funded research has been the principal catalyst in fostering industry interest in photovoltaic research. Without the advances resulting from DOE and industry R&D, the benefits cited would not be realized. What is more certain is that much of what remains of a U.S. market for photovoltaics would be lost to the Europeans and the Japanese, who present strong competition to the U.S. photovoltaic industry today.

Q24. Please provide a listing of the recipients of (i) the $8,986,000 in funding in FY 1995, (ii) the $9,945,000 in FY 1996 funding, and (iii) the requested level of $11,000,000 in FY 1997 for Photovoltaics Fundamental Research, including the funding for each recipient.

A24. The recipients are listed in the following table.

Photovoltaics Fundamental Research Funding Recipients
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
National Renewable Energy Laboratory	5,580	5,806	6,000
Duke University	153	138	
Georgia Institute of Technology	139	123	
University of California at Berkeley	124	136	
Massachusetts Institute of Technology	162	159	
University of South Florida	145	136	
North Caroline State University	92	110	
University of California at Los Angeles	90	110	
Research Triangle Institute	65	216	
North Caroline State University	160	132	
University of Illinois	145	91	
University of Utah	130	53	
University of South Florida	182	119	
Johns Hopkins University	136	75	
University of Delaware IEC	466	1,024	
Brookhaven National Laboratory - Environmental Safety & Health Research	380	300	400
Miscellaneous Contracts	0	584	
Small Business Innovative Research	837	633	
TBD	0	0	4,600
TOTAL	8,986	9,945	11,000

Q25. For each recipient of Photovoltaics Fundamental Research funds identified in the response to question 24 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A25. There is no cost-sharing in the fundamental research programs conducted at the laboratories or universities.

Q26. For those Photovoltaics Fundamental Research funding recipients listed in 24 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A26. Laboratory funding is based on a determination by DOE management that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the multi-year M&O contracts awarded through competitive procurements for the management of each laboratory. Non-competitive subcontract awards result from continuation of activities previously funded competitively, while others are awarded on the basis of unique expertise or exclusive capabilities. These non-competitive awards include Duke University, GIT, Berkeley, MIT, University of South Florida and North Carolina State University.

Q27. Please provide a listing of the recipients of (i) the $23,300,000 in funding in FY 1995, (ii) the $23,866,000 in FY 1996 funding, and (iii) the requested level of $28,000,000 in FY 1997 for Photovoltaics Advanced Materials and Devices, including the funding

for each recipient.

A27. The recipients are listed in the following table.

Photovoltaics Advanced Materials and Devices Funding Recipients
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
National Renewable Energy Laboratory	10,948	10,456	10,806
Siemens Solar Industries	769	309	
Solarex Corporation	430	379	
EPV Corporation	1,056	830	
AstroPower Corporation	750	675	
Energy Conversion Devices, Inc.	318	244	
United Solar, Inc.	891	834	
Golden Photon, Inc.	554	132	
Solar Cells, Inc.	956	673	
Penn State University	257	205	
Colorado State University	100	110	
University of Toledo	250	176	
Colorado School of Mines	363	210	
NIST, Boulder	157	145	
Harvard University	164	129	
Syracuse University	103	92	
University of Oregon	123	119	
Iowa State University	356	291	
University of North Carolina	103	71	
ISET	500	323	
University of Florida	270	102	
Sandia National Laboratories	1,500	1,000	1,000
Georgia Institute of Technology	500	500	
Golden Field Office Energy Conversion Devices	800	971	
Golden Field Office Utility PhotoVoltaic Group	0	4,200	
Miscellaneous Contracts	1,082	690	
TBD	0	0	16,194
TOTAL	**23,300**	**23,866**	**28,000**

Q28. For each recipient of Photovoltaics Advanced Materials and Devices funds identified in the response to question 27 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A28. The cost-sharing recipients are listed in the following table:

Photovoltaics Advanced Materials and Devices Funding Recipient Cost-Sharing
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
Siemens Solar Industries	769	309	TBD
Solarex Corporation	430	340	TBD
EPV Corporation	264	208	TBD
AstroPower Corporation	188	169	TBD
Energy Conversion Devices, Inc.	319	244	TBD

Recipient	FY 95	FY 96	FY 97
United Solar, Inc.	583	526	TBD
Solar Cells, Inc.	239	168	TBD
Golden Photon, Inc.	554	88	TBD
University of Toledo	20	20	TBD
Georgia Institute of Technology	120	120	TBD
Golden Field Office Energy Conversion Devices	759	943	TBD
Golden Field Office Utility PhotoVoltaic Group	0	8,862	TBD
TOTAL	4,245	11,997	**TBD**

Q29. **For those Photovoltaics Advanced Materials and Devices funding recipients listed in 27 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.**

A29. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the multi-year M&O contracts awarded through competitive procurements for the management of each laboratory. Non-competitive subcontract awards result from continuation of activities previously funded competitively, while others are awarded on the basis of unique expertise or exclusive capabilities. The only non-competitive award from the above recipients is Georgia Institute of Technology.

Q30. **Please describe the Photovoltaic Manufacturing Technology (PVMat) project, its progress and cost to date, expected date of completion, and expected results at completion. Also, please include both DOE and private sector funding.**

A30. The U.S. Photovoltaic Manufacturing Technology (PVMaT) Project is designed as a set of government/industry research and development (R&D) partnerships to advance photovoltaic manufacturing technology. The objectives of the project are to improve module manufacturing processes and equipment, and accelerate manufacturing cost reductions for photovoltaic modules and systems. Progress has been very successful. The weighted average module manufacturing cost has declined an estimated 56% and production capacity has increased by more than a factor of 6 in the last 4 years. Total cost to date has been $60.4 million with industry cost-share contribution of $45.6 million for a total project cost of $106 million. PVMaT will be completed by the end of FY 1997 for a total cost to DOE of $67.4 million. The expected results at completion will be a U.S. photovoltaic industry having advanced technology and manufacturing improvements capable of maintaining its world market competitiveness and increasing its economic impact in the U.S. as a result of growth in high technology jobs and exports.

Q31. **Please describe the Photovoltaics Building Opportunities in the U.S. (PV:BONUS) project, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.**

A31. The PV:BONUS project is a cost-shared program designed to assist the photovoltaic industry in developing additional near- and mid-term markets within the buildings sector.

Five cooperative agreements were initiated with industry in 1993. Each contract consists of a team of building materials manufacturers, building contractors, PV suppliers, system designers, architectural and engineering, firms, and building owners. Products under development include PV shingles for use on residential rooftops and glazing products for windows, skylights, and building exteriors that incorporate photovoltaics. The cost to date for DOE has been $7.5 million, with industry contributing cost share of $7.7 million for a total project cost to date of $15.2 million. Current PV:BONUS projects are planned to be completed in FY 1997 for a total cost to DOE of $10.2 million. When completed, all five products will have the potential to create significant new business in the buildings sector.

Q32. **Please describe the Utility PhotoVoltaic Group (UPVG) project, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.**

A32. The UPVG was formed in 1992 to accelerate the use of cost effective, small- and large-scale applications of PV for the benefit of electric utilities and their customers. The group currently has 84 members from all sectors of the electric utility industry. The Utility Photovoltaic Group administers a 50-megawatt photovoltaic hardware program designed to foster a sustainable utility market for PV. The first round of UPVG's solicitation for grid-connected applications resulted in 12 industrial contracts, totaling 5.9 MW of grid-connected PV installations, at a federal cost share of $6.5 million, or 20% of total project costs of $31.9 million. Ten or more PV technologies are represented in 340 installations located in 12 states.

The UPVG is a six-year program scheduled for completion in fiscal year 2000, at which time 50 megawatts of new PV installations are planned to be completed. The cost of completion is $41 million to DOE and $107 million to industry (28/72 cost share).

Q33. **Please describe the PV-COMPACT program, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.**

A33. PV-COMPACT (PhotoVoltaic COllaborative Market Project to Accelerate Commercial Technology) is a unique collaborative effort involving a broad spectrum of organizations with an interest in solar electric technology. These organizations are the utility industry, the photovoltaic industry, utility regulators, consumer advocates and state energy offices. Their objectives are to provide technical, financial and institutional support necessary to initiate, maintain and expand activities at the state and local level that will increase understanding of the value of photovoltaics and help resolve market barriers. PV-COMPACT is a five-year program that supports UPVG's efforts to install 50 MW of photovoltaic systems by the year 2000. DOE funding for PV-COMPACT has been $600 thousand per year since FY 1994. The cost to date has been $1.8 million, and total funding at completion in FY 1999 will be $3 million. Together with UPVG's efforts, PV-COMPACT is a market acceleration effort aimed at reducing CO_2 emissions by 0.5 million metric tons in the year 2000 and generating energy savings of 0.03 quads valued at $104 million.

Q34. Please provide a listing of the recipients of (i) the $51,549,000 in funding in FY 1995, (ii) the $27,748,000 in FY 1996 funding, and (iii) the requested level of $47,994,000 in FY 1997 for Photovoltaics Collector Research and Systems Development.

A34. The recipients are listed in the following table.

Photovoltaics Collector Research and Systems Development Funding Recipients
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
National Renewable Energy Laboratory	6,617	5,148	6,000
AstroPower Corporation	2,695	1,318	
Golden Photon, Inc.	1,430	1,237	
Solarex Corporation	1,134	774	
Springborn Laboratories	457	0	
Solar Cells, Inc.	100	500	
Solar Design Associates	449	273	
Omnion Power Engineering Corp.	378	300	
Ascension Technology, Inc.	603	76	
Utility Power Group	492	137	
Evergreen Solar, Inc.	450	31	
Skyline Engineering	443	22	
Iowa Thin Film Technologies, Inc.	938	265	
SEA Corporation	250	1,073	
Siemens Solar Industries	350	495	
ASE Americas, Inc.	0	435	
Solar Electric Light Fund	150	100	
Applied Power	0	201	
Spire Corporation	694	0	
University of Delaware	249	0	
New World Power	263	0	
Bergey Windpower	454	0	
New Resources Group	345	0	
DOE Golden Field Office	0	0	
Energy Conversion Devices	1,953	2,046	
FIRST, Inc.	275	177	
Delmarva Power & Light	356	76	
Solar Design Associates	695	440	
Innovative Design	225	30	
Pacific Gas & Electric	970	750	
Georgia Institute of Technology	1,750	0	
Southern California Edison	1,500	500	
USAPV	304	0	
Utility PhotoVoltaic Group	8,891	1,200	
Sacramento Municipal Utility District	1,100	0	
Wal-Mart Corporation	100	0	
Solar Energy Industries Association	892	650	
Sandia National Laboratories	8,900	6,200	7,200
Florida Solar Energy Center	450	350	
SW Regional Experiment Station	450	450	
Boston Support Office	1,283	600	
Miscellaneous Contracts	2,514	1,894	
TBD	0	0	34,794
TOTAL	51,549	27,748	47,994

Q35. For each recipient of Collector Research and Systems Development funds identified in the response to question 34 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997, including the funding for each recipient.

A35. The cost-sharing recipients are listed in the following table.

Photovoltaics Collector Research and Systems Development
Funding Recipient Cost-Sharing
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
AstroPower Corporation	1,896	927	TBD
Golden Photon, Inc.	1,430	1,237	TBD
Solarex Corporation	1,134	901	TBD
Springborn Laboratories	196	0	TBD
Solar Cells, Inc.	100	500	TBD
Solar Design Associates	158	96	TBD
Omnion Power Engineering Corp.	100	80	TBD
Ascension Technology, Inc.	249	51	TBD
Utility Power Group	123	34	TBD
Evergreen Solar, Inc.	113	9	TBD
Skyline Engineering	104	5	TBD
Iowa Thin Film Technologies, Inc.	402	114	TBD
SEA Corporation	107	460	TBD
Siemens Solar Industries	350	495	TBD
ASE Americas, Inc.	0	653	TBD
Solar Electric Light Fund	100	100	TBD
Applied Power	201	200	TBD
Energy Conversion Devices	1,882	2,224	TBD
FIRST, Inc.	362	233	TBD
Delmarva Power & Light	643	76	TBD
Solar Design Associates	609	439	TBD
Innovative Design	225	30	TBD
Georgia Institute of Technology	1,750	0	TBD
Southern California Edison	1,500	500	TBD
USAPV	658	0	TBD
Utility PhotoVoltaic Group	9,337	2,538	TBD
Sacramento Municipal Utility District	3,370	0	TBD
Wal-Mart Corporation	134	0	TBD
TOTAL	**27,233**	**11,902**	**TBD**

Q36. For those Photovoltaics Collector Research and Systems Development funding recipients listed in 34 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A36. Laboratory funding is based on a determination by DOE management that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the multi-year M&O contracts awarded through competitive procurements for the management of each laboratory. Non-competitive subcontract awards result from continuation of activities previously funded competitively, while others are awarded on the basis of unique expertise or exclusive capabilities. These non-competitive awards include the Florida Solar Energy Center, SW Regional Experiment Station, Solar Electric Light Fund, Ascension Technology, Spire Corporation, University of Delaware and the New Resources Group.

Solar Thermal Energy Systems

Q37. Page 493 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the DOE Solar Thermal Electric program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.00 Q**	**0.07 Q**	**0.34 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$9 M**	**$472 M**	**$2,360 M**
Carbon Equivalent Emissions Reductions	**0.02 MMT**	**1.00 MMT**	**2.00 MMT**

Q37a. Please provide detailed documentation of these claimed benefits.

A37a. The above projected benefits result from an intensive internal effort to develop peer-review metrics of the impacts of renewable energy and energy efficiency prorams at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity from solar thermal which were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1995. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q37b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A37b. The benefits cited are based on past and expected future technology improvements resulting from DOE support of R&D conducted by the National Laboratories and U.S. industry. The DOE-supported research addresses the most critical technical and customer-acceptance issues in Solar Thermal. We cannot state with certainty that all private research efforts would cease without the Federal program, but we do know that the Federally funded research has been the principal catalyst in fostering industry interest in Solar Thermal research. Without the advances resulting from DOE and industry R&D, the benefits cited would not be realized.

Q38. Please describe the 7-kW dish/Stirling program, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A38. The 7-kWe dish/engine system has been developed through an $18.3 million, 5-year, 50/50 cost-shared project with Cummins Power Generation, Inc. (Cummins). The project, which began in May 1991, is targeted at remote and off-grid power markets. In FY96, Cummins is initiating the testing of six Phase III (manufacturing prototype) 7-kW units, including a unit at the Summer Olympics in Atlanta. This is the last phase of the five-year contract and DOE's cost-shared portion of this project will be completed this year. Cummins is proceeding with business plans for their systems and anticipates having commercially available units by 1998/1999.

Q39. Please describe the 25-kW dish/Stirling program, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A39. DOE has two $36M 50/50 cost-shared contracts, one with Cummins and the other with Science Applications International Corporation (SAIC), which are directed at developing 25-kWe dish/Stirling systems for both domestic and international utility markets. These are 5-year contracts which started in FY94. Including FY96 funding, DOE has contributed $16.3M to these projects. Installation of 5 second-generation 25-kWe dish/Stirling prototype systems at a grid-connected site in California will begin in late FY96, with additional installations scheduled for 1998/1999. These projects are scheduled for completion in 1999. These installations will validate the dish/engine technology and serve as a showcase for both domestic and international purchasers interested in pursuing commercial ventures.

Q40. Please describe the Solar Two Power Tower, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A40. In 1992, a consortium of U.S. utilities led by Southern California Edison Company (SCE) initiated a cooperative project with DOE and industry. The objective was to retrofit the existing 10 MWe Solar One Power Tower Pilot Plant, which was operated from 1982 to 1987, to add at least three hours of energy storage capability utilizing molten nitrate salt technology. Successful operation of the converted plant, called Solar Two, will show that power towers can provide dispatchable power, which is of great interest to utilities. Joining SCE and DOE in sponsoring this project are a number of industrial, municipal, and utility partners. The estimated cost of Solar Two, including its three-year test and evaluation period, is $50 million, which is being cost-shared 50/50 between DOE and industry participants. Including FY96 funding, DOE has contributed $20 million to these projects, with two years of test and operations yet remaining. The plant started operations in January 1996. Successful operation of Solar Two will validate molten-salt thermal storage technology and provide domestic and international representatives the opportunity to experience power tower technology in action, thus reducing the associated financial and operational risks and removing the barriers to commercialization.

Q41. Please describe the SolMat initiative, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A41. The SolMat Initiative is aimed at assisting the manufacturers of solar thermal components to reduce the costs of low-volume early commercial applications. The first two SolMat contracts, which were issued in early FY 1995, involve manufacturing techniques for heliostats. Two other SolMat contracts, issued in FY 1996, involve receivers and concentrators. Phase I & II of these contracts, currently involving $6.4 million, are being cost-shared on a 4 to 1 (DOE/Industry) ratio over a three-year period. Including FY96 funding, DOE has contributed $4.5 million to these projects. SolMat will reduce uncertainty in the cost and reliability of key solar components while promoting the development of business plans and industry partnerships, leading to successful commercial ventures.

Q42. Please provide a listing of the recipients of (i) the $7,208,000 in funding in FY 1995, (ii) the $6,768,000 in FY 1996 funding, and (iii) the requested level of $5,800,000 in FY 1997 for Solar Thermal Systems Research, including the funding for each recipient.

A42. The recipients are listed in the following table:

Solar Thermal Research Funding Recipients
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
Sandia National Laboratories	5,066	4,969	4,573
National Renewable Energy Laboratory	2,142	1,799	1,227
TOTAL	7,208	6,768	5,800

Q43. For each recipient of Solar Thermal Systems Research funds identified in the response to question 42 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A43. Funding for Solar Thermal Systems Research is provided to the National Laboratories to conduct applied research which is not cost-shared by industry.

Q44. For those Solar Thermal Systems Research funding recipients listed in 42 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A44. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q45. Please provide a listing of the recipients of (i) the $16,323,000 in funding in FY 1995, (ii) the $12,478,000 in FY 1996 funding, and (iii) the requested level of $17,950,000 in FY 1997 for Solar Thermal Power Applications Research, including the funding for each recipient.

A45. The recipients are listed in the following table.

Solar Thermal Research Funding Recipients
(In Thousands of $)

Recipient	FY 95	FY 96	FY 97
Cummins Power Corporation (CPC)	1,565	1,421	
CPG & Science Applications International Corp. (SAIC)	7,968	5,757	
Southern California Edison, et al.	2,228	2,855	
SAIC, Solar Kinetics, McDonell Douglas, Rockwell (SolMat)	2,534	1,530	
Kramer Junction Company	1,025	0	
Sandia National Laboratories/National Renewable Energy Lab.	703	705	990
Various Small Projects (Design Assistance)	300	210	
TBD	0	0	16,960
TOTAL	16,323	12,478	17,950

Q46. For each recipient of Solar Thermal Power Applications Research funds identified in the response to question 45 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A46. All of the major solar thermal projects are cost-shared 50/50 with industry, with the exceptions of SolMat, which is 75/25, and Design Assistance projects, which is 75/25.

Q47. For those Solar Thermal Systems Research funding recipients listed in 45 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A47. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Funds for all of the major solar thermal projects are competitively awarded.

Q48. Please provide a listing of the recipients of (i) the $3,119,000 in funding in FY 1995, and (ii) the $2,777,000 in FY 1996 funding for Solar Detoxification, including the funding for each recipient.

A48. The amount for Solar Detoxification in FY 1995 was $3,230,000 after all contracts were negotiated. The additional $111,000 was taken from Industrial Processes. The amount of funding for Solar Detoxification in FY 1996 was reduced from $2,777,000 to $2,519,000 due to a Congressional recession of $258,000. See table below for recipients.

Q49. For each recipient of Solar Detoxification funds identified in the response to question 48 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1996.

A49. See table below.

Q50. For those Solar Detoxification funding recipients listed in 48 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A50. See table below.

Q51. Please provide a listing of the recipients of (i) the $3,666,000 in funding in FY 1995, and (ii) the $2,247,000 in FY 1996 funding for Solar Industrial Processes, including the funding for each recipient.

A51. The amount for Solar Industrial Processes in FY 1995 was $3,555,000, after contracts were negotiated. The other $111,000 was used for Solar Detoxification. See table below for each recipient.

Q52. For each recipient of Solar Industrial Processes funds identified in the response to question 51 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1996.

A52. See table below.

Q53. For those Solar Industrial Processes funding recipients listed in 51 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A53. See table below.

Solar Industrial Contracts and Cost-Share
(In Thousands of $)

FY	PROJECT	RECIPIENT	VALUE	COST-SHARE	COMPETITIVE	JUSTIFICATION
95	Detox	DOE	286	0	No	SBIR, Program support.
95	Detox	Massachusetts Institute of Technology (MIT)	40	0	No	Development of Nanocrystalline Titania Photocatalysts. Specialized equipment for studying and developing new catalysts.
95	Detox	NREL	1,950	4,000*	No	National Laboratory with unique capabilities.
95	Detox	Sandia	264	0	No	National Laboratory with unique capabilities.
95	Detox	Solarchem Environmental Systems	164	16	No	Solarchem has a patent on a unique homogeneous process for destroying organic wastes in groundwater.
95	Detox	Univ. of Arizona	80	0	Yes	
95	Detox	Univ. of Arizona	43	0	Yes	
95	Detox	Univ. of Colorado	68	0	No	Continuation of existing contract: gas-phase fundamental reaction studies of oxidation on TiO_2 surfaces.
95	Detox	Univ. of Colorado	65	0	No	Continuation of existing contract: gas-phase fundamental reaction studies of oxidation on TiO_2 surfaces.
95	Detox	Univ. of Colorado at Boulder	80	0	No	Unique capability for application of Surface Enhanced Raman Spectroscopy
95	Detox	Univ. of Colorado at Boulder	60	0	No	Continued support of fundamental studies for high-temperature destruction of hazardous wastes.
95	Detox	Univ. of Texas at Arlington	70	0	Yes	
95	Detox	Univ. of Texas at Austin	60	0	Yes	
		TOTAL, DETOX	**3,230**	**4,016**		
95	Ind	Advanced Thermal Systems	34	0	No	Exclusive hardware/software capability.
95	Ind	American Energy Tech.	20	66	No	Facilitate penetration of US solar tech. into Caribbean market.
95	Ind	DOE	296	0	No	SBIR, Program support.
95	Ind	Domestic Tech. Int'l	60	0	Yes	Phase 2 of a competitive bid study for Solar Process Heat (SPH) market studies.
95	Ind	Domestic Tech. Int'l	42	0	Yes	Won a competitive bid study for Solar Process Heat (SPH) market studies.

FY	PROJECT	RECIPIENT	VALUE	COST-SHARE	COMPETITIVE	JUSTIFICATION
95	Ind	Healey & Associates	40	0	Yes	Won a competitive bid study for SPH market studies.
95	Ind	Industrial Solar Tech.	71	141	Yes	Phase 2 of a competitive bid study for SPH market studies.
95	Ind	Infinite Energy	5	0	Yes	
95	Ind	Virginia	41	160	No	Collaboration with Virginia.
95	Ind	California	50	30	No	Collaboration with California.
95	Ind	California Energy Com.	50	50	Yes	
95	Ind	Fort Huachuca	25	175	No	Collaboration with Army.
95	Ind	Industrial Solar Tech.	28	28	Yes	
95	Ind	New Mexico	20	20	No	Collaboration with New Mexico.
95	Ind	Packerland Solar	20	20	No	Technical assistance to large operating solar system.
95	Ind	Florida Solar Energy Center	70	0	No	Unique analysis capability.
95	Ind	Sandia A&E	40	0	Yes	
95	Ind	North Carolina State Univ.	30	0	No	Unique tax benefits make NC key state for SPH applications.
95	Ind	NREL	1,419	413**	No	National Laboratory with unique capabilities.
95	Ind	Sandia	321	0	No	National Laboratory with unique capabilities.
95	Ind	Science Applications International Corporation	25	0	No	Analysis capability not available elsewhere.
95	Ind	SEIA	222	0	No	SEIA is only professional trade organization to represent SPH.
95	Ind	Shooshanian	29	0	Yes	Won a competitive bid study for SPH market studies.
95	Ind	Solar Enterprises Int'l	30	30	No	SEI owns rights to collector technology developed under subcontract.
95	Ind	To Award-Tech Dev RFP	478	45	Yes	
95	Ind	United Solar Technology	24	0	Yes	Won a competitive bid study for SPH market studies.
95	Ind	University of Chicago	65	0	No	Unique optics modeling and fabrication capability.
		TOTAL, INDUSTRIAL PROCESS	3,555	1,178		
96	Detox	DOE	232	0	No	SBIR, Program support.
96	Detox	Miscellaneous small contracts	27	0	Yes	

FY	PROJECT	RECIPIENT	VALUE	COST-SHARE	COMPETITIVE	JUSTIFICATION
96	Detox	NREL	1,967	344*	No	National Laboratory with unique capabilities.
96	Detox	Sandia	293	0	No	National Laboratory with unique capabilities.
		TOTAL, DETOX	**2,519**	**344**		
96	Ind	Advanced Thermal Systems	18	0	No	Exclusive hardware/software capability.
96	Ind	California Department of Corrections	132	3,468	Yes	
96	Ind	Conserval	18	53	No	Proprietary position in project by industry.
96	Ind	DOE	203	0	No	SBIR, Program support.
96	Ind	Garden Grove Prison	36	107	No	Proprietary position in project by industry.
96	Ind	MesoAmerica	30	120	No	Proprietary position in project by industry.
96	Ind	Miscellaneous small contracts	281	0	Yes	
96	Ind	New Mexico Energy Office	35	254	No	State Energy Office.
96	Ind	NREL	1,119	0	No	National Laboratory with unique capabilities.
96	Ind	Sandia	260	0	No	National Laboratory with unique capabilities.
96	Ind	Science Applications International Corporation	79	0	No	Analysis capability not available elsewhere.
96	Ind	Suntrapper	36	106	No	Proprietary position in project by industry.
		TOTAL, INDUSTRIAL PROCESS	**2,247**	**4,108**		

*Note: Cost-share shown under NREL is industry cost-share for collaborations with NREL and Sandia that did not involve contract $, such as CRADAs. All cost-share is shown under NREL for simplicity; both NREL and Sandia had CRADAs and other industry collaborations.

**Note: Cost-share shown is for collaborations in which the DOE cost-share was the technical support by NREL and Sandia.

Biofuels Energy Systems

Q54. On page 503 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The currently installed biomass power generating capacity stands at approximately 7,000 MW. It is expected that by 2000, up to an additional 2,000 MW will be installed. By 2010, it is predicted that 8,000 MW of new capacity additions will be added, growing to a total of 30,000 MW of newly installed capacity by 2020."

A54a. Please provide documentation for these estimates.

A54a. Independent assessments of the future potential for biomass power capacity additions have been put forth by various independent organizations. The Union of Concerned Scientists has published a document entitled Powering the Midwest, Renewable Electricity for the Economy and the Environment (1993), which speaks specifically to the emerging opportunities in rural America for greatly enhanced baseload biomass power applications. Opportunities in the pulp and paper industry have been addressed in a report prepared for the Electric Power Research Institute (EPRI) titled Paper Recycling: Impact on Electricity-use, Electro-technology Opportunities (RP-3328-06, April 1993). This report details the significant opportunities for the pulp and paper to transition from being power importers, to become power exporters. Additionally, projected upward pressure on natural gas prices after 2010 has increased the EIA forecast market penetration of biomass by 2015, thus serving to positively impact the use of biomass power technologies as well.

Q54b. Please compare these estimates with the biomass estimates contained in the EIA's *Annual Energy Outlook 1996*, and explain any differences.

A54b. The DOE and EIA estimates are provided in the following table:

Recipient	2000	2010	2020
EIA Projection	+280 MW	+1,530 MW	N/A
DOE Projection	+2,000 MW	+8,000 MW	+30,000 MW

Through cost-shared development projects with the private sector, the Department's Biomass Power Program is directly participating in the development of between 154 MW and 284 MW of new biomass power capacity, projected to come on line in the 2000-2001 time frame. These first-of-a-kind demonstrations will prove the technical viability of advanced technology, high-efficiency biomass power systems and demonstrate a viable new revenue stream for America's farmers. The pulp and paper industry also plans to move from being power importers to power exporters. It is believed that these contributing factors in the cogeneration and farming sectors will result in a five-fold increase over EIA projected biomass power capacity additions.

Q55. Page 504 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the DOE Biomass Power R&D–Utilities program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.09 Q**	**0.43 Q**	**1.86 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$630 M**	**$3,039 M**	**$13,026 M**
Carbon Equivalent Emissions Reductions	**2.03 MMT**	**8.91 MMT**	**36.62 MMT**

Q55a. Please provide detailed documentation of these claimed benefits.

A55a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity from biomass power technologies. These projections of the cost of electricity from biomass power technologies were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1995. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q55b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A55b. The benefits cited are primarily based on the commercialization of advanced biomass gasification/gas turbine technologies and integrated biomass (dedicated feedstock) systems. Without the DOE programs these technologies would not have a significant impact in the time frame of the benefits projections and the cited benefits would not occur.

Q56. Please describe the "[t]wo advanced concept gasification systems . . . being validated for performance and availability in the late 1990s" (page 504 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), their progress and costs to date, expected date and cost of completion, and expected results at completion.

A56. The Department is currently pursuing the development of two advanced concept gasification systems, both of which will be validated in the late 1990s. The Hawaii Biomass Gasifier Facility is scaling up the Institute of Gas Technology's "direct" gasification technology. There is strong international competition in the development of direct biomass gasification systems, with at least three European development projects currently underway. This project is unique in that it incorporates a high temperature gas cleaning technology which will enable higher total system conversion efficiencies than its competitors (competing systems must first cool the gas before cleanup and this loss of heat lowers the system efficiency). Westinghouse Electric Corp., which is developing the biomass Hot Gas Cleanup Unit, is transferring, high temperature gas cleanup technology development efforts from the Fossil Energy/Clean Coal Program, thus serving to leverage investments made through other DOE programs. While the current efforts focus on air gasification for power generation, the system can incorporate an oxygen unit which will facilitate methanol production. As such, with further development, this unit can potentially serve both power generation and/or alternative fuels markets. (Please see the response to question 58 below for further details on project progress and cost).

The Vermont Gasifier Project is scaling up the Battelle Columbus "indirect" gasification technology. While this technology is less mature than "direct" gasification systems, it is the only system successfully utilized to power an essentially unmodified gas turbine (accomplished through DOE-partnered efforts in 1994). The primary benefits of indirect gasification are that a higher heating value gas is produced (leading to higher total system efficiencies and a more cost-competitive nature), and the gas can be effectively cleaned with catalysts and traditional scrubbing technology (which has already been demonstrated). Beyond power generation via gas turbines, preliminary studies show that this system (which is unique with respect to any competition) offers outstanding potential when integrated with high temperature molten carbonate fuel cells, thus offering another significant market entry opportunity. (Please see the response to question 59 below for further details on project progress and cost.)

Q57. Please describe the "Biomass Power for Rural Development" initiative (page 504 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), its progress and cost to date, its expected date and cost of completion, and expected results at completion.

A57. The "Biomass Power for Rural Development" initiative is a collaborative effort with USDA, aimed at demonstrating the technical and economic viability of integrated biomass power systems, consisting of projects that produce high-yielding biomass feedstocks which are then utilized in advanced biomass power conversion facilities. Through this initiative, DOE and USDA will award up to four cost-shared, multi-partner, industry led projects in FY 1996, with an additional 2-3 awards possible in FY 1997. Projects selected for award are chosen through a competitive solicitation process, and announcements are anticipated in June/July 1996. In total, these projects will bring on line over 175 MW of renewable biomass power, sustained by over 200,000 acres of dedicated energy crops, by 2001. Through FY 1996, the Program will have provided $6.017M in cost-shared funding. Over the life of these projects, DOE's $80M investment will leverage almost $250M in private-sector investment. The overall objective of these projects is to validate the economic and environmental benefits of integrated biomass power deployments, with a particular emphasis on the realization of benefits in rural areas where development opportunities are scarce.

Q58. Please describe the "Hawaii Biomass Gasifier Facility" (page 504 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), its progress and cost to date, its expected date and cost of completion, and expected results at completion.

A58. The goal of the Hawaii Biomass Gasifier Facility is to design, construct and operate, through a cost-shared venture with a private-sector partner, an advanced prototype "direct" biomass gasifier combined with a Hot Gas Cleanup system, through which scale-up and operating data can be obtained. These data will serve to validate the commercial feasibility of the gasification and gas cleanup technologies, and lay the foundation for a commercial development strategy. This multi-partner, cost-shared project was initiated in September 1991, and is located at the Paia Plantation of HC&S on the island of Maui in the State of Hawaii. Phase I of this project includes construction and operation of the gasifier, and was completed in October 1995. Total project costs, from FY 1991 through anticipated project completion in FY 2000 (which includes the critical scale-up to a 20 MW facility) are estimated to be $65.7 million. DOE's cost-shared investment in this project to date is $11.9 million and is expected to total $24.9 million. The efforts undertaken through this cost-shared venture will technically and operationally validate an advanced prototype biomass gasification/gas turbine technology, and facilitate a strong presence for a U.S.-based industry to capture emerging domestic and worldwide power market opportunities.

Q59. Please describe the "Vermont Project" (page 504 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), its progress and cost to date, its expected date and cost of completion, and expected results at completion.

A59. The goal of the Vermont Project is to validate an "indirect" gasification technology that will also further enable biomass energy to be used with advanced gas turbine power generation systems. The intent is to scale-up and validate the Battelle Gasification technology at the existing McNeil Power Station in Burlington, VT, with the inclusion of a 15 MW gas turbine for complete system testing. Phase I of the project (detail engineering design) was completed ahead of schedule in May 1995. Phase II (construction and operational testing) is currently underway. The final phase, Phase III (inclusion of the gas turbine) is scheduled to be initiated in January 1997. Total project costs, from FY 1995 through anticipated project completion in FY 1999, are expected to be approximately $33.6 million. DOE's cost-shared investment in this project to date is $12.7 million and is expected to total approximately $15.6 million. Upon project completion, this effort will have validated an advanced biomass gasifacion/gas turbine technology, and facilitate a strong presence for a U.S.-based industry to capture emerging domestic and worldwide power opportunities.

Q60. Please describe the Advanced Turbine Systems (ATS)/Biomass for Cogeneration project (page 506 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), its progress and cost to date, its expected date and cost of completion, and expected results at completion.

A60. The Advanced Turbine System(ATS) Program will develop the next generation of land-based turbine system for both utility and industrial applications, including cogeneration. The goal of the program is to design, develop and demonstrate advanced turbine systems that will be more efficient, environmentally superior, and will produce electricity costing 10 per cent less at the busbar. The goal of the Biomass for Cogeneration project is to allow biomass derived fuels to be burned in a gas turbine. Switching from clean natural gas to biomass fuels in gas turbines is a significant change. The biomass derived fuels contain corrosive species which rapidly degrade gas turbine performance. To reach the goal requires development in two critical areas: gas clean-up and ruggedizing the turbine to improve corrosion and erosion resistance.

Progress to date: Since the project began in FY 96, two studies on converting combustion turbines from natural gas to biomass have been completed. In addition, projects have been put in place to develop thermal barrier coatings and improved airfoil castings that will have increased corrosion resistance, cost, life and ease of fabrication.

Cost to date: $1.2M(project started in FY 96)
Cost to completion: $14M
Expected results: Demonstrate an Advanced Turbine System that could be adapted to biomass-derived fuels in 2000.

Q61. Page 507 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the DOE Biomass–Industry program at the proposed funding levels:

	2000	2010	2020
Energy Savings (quad/year)	**.02**	**.05**	**0.1**
Cost Savings ($M/year)	**75**	**325**	**700**
Carbon Reduction (Million ton/year)	**1.9**	**3.8**	**5.2**

Q61a. Please provide detailed documentation of these claimed benefits.

A61a. DOE makes extensive use of Energy, Economic and Environmental models to identify which projects are appropriate to receive federal funding and to quantify the benefits resulting from these projects. The model performs a financial analysis based on a comparison of cost, energy and environmental data for the conventional versus the new technology. Using these financial results and target market data, the model predicts market penetration of the new technology over the next 25 years. Based on the market penetration results, the model then calculates the potential energy savings, cost savings and waste reduction over the next 25 years. Once the benefits have been quantified they are distributed to experts inside and outside of DOE for peer review. The discrepancies from the peer review findings are resolved and the benefits are finalized.

Input for the models comes from a variety of sources inside and outside of DOE. The ATS/Biomass for Cogeneration pro-ram benefits are based upon Energy Information Administration (EIA) forecasts and the cost and efficiency goals of the program. EIA's "Annual Energy Outlook 1996" (DOE/EIA-0383(96)) was used to determine demand for baseload and reserve electric power. Capital and operating costs for conventional technology wee drawn from a variety of sources, such as annual Power and Gas Turbine World handbooks. Program plans are used to estimate costs for biomass systems in 2000 and beyond.

Q61b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A61b. These benefits would not be realized without advancements in biomass/gas turbine technology. These advancements will not occur without DOE funding. The Advanced Turbine Systems(ATS) grew out of a series of workshops at Clemson University in 1991-92. These workshops documented that left to their own devices the gas turbine manufacturers would not take on the risk of developing gas turbines for biomass applications on their own. They stated their limited internal R&D resources would be spent in two areas; first cost and durability. Since the 1980's global competition has been fierce in the gas turbine business. Many have either lost money or are operating at margins as low as 5%. With these small margins there is very little resources available to spend on any long-term technology development. Also most manufacturers are turning to the global market where the customer's major concern is first cost, not developing renewable energy sources. Without DOE funding the U.S. will not receive the tremendous benefits gas turbine and biomass technology brings to the nation in developing a sustainable economy and environment.

Q62. Page 509 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the DOE Biomass–Transportation program at the proposed funding levels:

	2000	**2010**	**2020**
Primary Energy Displaced (Quads)	**0.03**	**0.87**	**1.27**
Primary Oil Displaced (MBPD)	**0.01**	**0.41**	**0.60**
Energy Cost Savings ($B)	**0.0**	**0.08**	**1.05**
Carbon Reductions (MMTons)	**0.57**	**15.7**	**18.8**

Q62a. Please provide detailed documentation of these claimed benefits.

A62a. To estimate the market impact of ethanol fuel and alternative vehicle technologies that utilize ethanol, estimations of fuel and vehicle attributes were made for conventional and advanced technologies.[1] These estimations were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations.[2] Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model.[3] The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle stocks (miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using AVS 8.1, it was estimated that flex-fuel light duty vehicles would enter the market in 1997, dedicated conventional ethanol vehicles in 2002, and fuel cell vehicles in 2008. The following table details the results from AVS 8.1.

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996. Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Fulton, Lewis M. "Alternative-Fuel Vehicles and The Energy Policy Act: A Case Study In Technology Policy." Diss. U. of Pennsylvania, 1994.

[3] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ ESD/TM-93), Argonne National Laboratory, Argonne, IL, December 1994.

Market Penetration	2000	2010	2020
Flex-Fuel Vehicles	41%	16%	15%
Percent of Total Flex-Fuel Use Ethanol	7%	28%	41%
Dedicated Conventional Vehicles	0%	3%	4%
Fuel Cell Vehicles	0%	4%	14%

The market penetration results were used to generate the following vehicle, fuel, and emissions impacts:

Percent of Total Light Duty Vehicles	2000	2010	2020
Flex-Fuel Vehicles	7%	19%	15%
Dedicated Conventional Vehicles	0%	1%	3%
Fuel Cell Vehicles	0%	1%	8%

By year 2010, ethanol vehicles account for 42.6 million light duty vehicles in use.

Biomass Ethanol Fuel Use (MBPD)	2000	2010	2020
Flex-Fuel Vehicles	0.01	0.32	0.32
Dedicated Conventional Vehicles	0.00	0.05	0.11
Fuel Cell Vehicles	0.00	0.02	0.13
Total	**0.01**	**0.39**	**0.56**

Gasoline Displaced (MBPD)	2000	2010	2020
Flex-Fuel Vehicles	0.01	0.32	0.32
Dedicated Conventional Vehicles	0.00	0.07	0.15
Fuel Cell Vehicles	0.00	0.02	0.13
Total	**0.01**	**0.41**	**0.60**

Additional gasoline displacement from fuel cell vehicle efficiency improvements are not included above.

Energy Cost Savings ($Billion)	2000	2010	2020
Flex-Fuel Vehicles	-0.12	-0.33	0.10
Dedicated Conventional Vehicles	0.00	0.40	0.96
Total	**-0.12**	**0.07**	**1.06**

Energy cost savings accrued by the fuel cell technology are not included in the biofuels estimate.

Carbon Reductions (MMTons)	2000	2010	2020
Flex-Fuel Vehicles	0.57	12.79	12.83
Dedicated Conventional Vehicles	0.00	2.96	6.06
Total	**0.57**	**15.75**	**18.89**

Carbon reductions for the fuel cell technology are not included in the biofuels estimate.

Q62b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A62b. The benefits that are estimated for the biomass program do not include any alcohols produced from corn. It is probable that, if the DOE funding were stopped, no ethanol other than that based on corn would continue. The ethanol that might be produced from waste and from specially grown grasses and trees would not materialize without the DOE funding.

Q63. Please provide a listing of the recipients of (i) the $2,296,000 in funding in FY 1995, (ii) the $2,125,000 in FY 1996 funding, and (iii) the requested level of $2,790,000 in FY 1997 for Biomass Power R&D–Utilities Thermochemical Conversion, including the funding for each recipient.

A63. The major recipients of the Biomass Power R&D–Utilities Thermochemical Conversion funding are depicted in the following table:

Biomass Power R&D–Utilities Thermochemical Conversion Funding Recipients

MAJOR RECIPIENT	FY 95	FY 96	FY 97
National Renewable Energy Laboratory	$890,000	$1,393,000	$2,346,000
Westinghouse Electric Corp.	$950,000		
Pacific International Center for High Technology Research (PICHTR)	$200,000		
Hawaii Natural Energy Institute/University of Hawaii	$60,000		
Sandia National Laboratories		$448,000	$444,000
Fuel Cell Developer to be determined		$244,000	
TOTAL	$2,100,000	$2,085,000	$2,790,000

Q64. For each recipient of Biomass Power R&D–Utilities Thermochemical Conversion funds identified in the response to question 63 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A64. Funding provided to the National Laboratories and the HNEI/University of Hawaii is not cost-shared. The $200,000 provided to the Pacific International Center for High Technology Research (PICHTR), and the $950,000 provided to Westinghouse is utilized in conjunction with the Hawaii Biomass Gasification Facility, and is matched 50/50 by private-sector contributions through the project.

Q65. For those Biomass Power R&D–Utilities Thermochemical Conversion funding recipients listed in 63 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A65. National Laboratory funding is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q66. Please provide a listing of the recipients of (i) the $11,901,000 in funding in FY 1995, (ii) the $18,437,000 in FY 1996 funding, and (iii) the requested level of $32,560,000 in FY 1997 for Biomass Power R&D–Utilities Systems Development, including the funding for each recipient.

A66. The major recipients of the Biomass Power R&D–Utilities Systems Development funding are depicted in the following table:

Biomass Power R&D–Utilities Systems Development Funding Recipients

Recipient	FY 95	FY 96	FY 97
Pacific International Center for High Technology Research (PICHTR)	$2,000,000	$3,593,000	
Future Energy Resources Corporation (FERCO)	$4,823,000	$7,826,000	
Power Generation Incorporated (PGI)	$275,000		
National Renewable Energy Laboratory	$2,460,000	$1,402,000	$1,112,000
Sandia National Laboratories (SNL)	$400,000		
Oak Ridge National Laboratory (ORNL)	$450,000	$487,000	$468,000
Biomass Power for Rural Development Initiative competitive solicitation-TBD and others		$5,196,000	$30,980,000
TOTAL	**$10,408,000**	**$18,504,000**	**$32,560,000**

Q67. For each recipient of Biomass Power R&D–Utilities Systems Development funds identified in the response to question 66 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A67. Project cost-sharing by recipient for each of FY 1995-FY 1997 is identified in the table below:

Biomass Power R&D–Utilities Systems Development Funding Recipient Cost-Sharing

Recipient	FY 95	FY 96	FY 97
Pacific International Center for High Technology Research (PICHTR)	$92,194	$1,967,000	TBD
Future Energy Resources Corporation (FERCO)	$1,784,132	$4,690,250	TBD
Power Generation Incorporated (PGI)	$250,000		
Biomass Power for Rural Development Initiative competitive solicitation-TBD and others		TBD	TBD
TOTAL	**$2,126,326**	**TBD**	**TBD**

Q68. For those Biomass Power R&D–Utilities Systems Development funding recipients identified in the response to question 66 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A68. In the 1994 Energy Appropriations budget, DOE was given direction (within Title III of the Conference Report, H.R. Rep. No. 103-305 to accompany H.R. 2445) to pursue "cost-shared validation of direct combustion technologies including gasification technologies, injected turbines.... with a more industry-driven focus." Following this direction, the Department of Energy received an unsolicited proposal from Future Energy Resources Corporation (FERCO, of Atlanta, GA) proposing the cost-shared development of an advanced prototype biomass gasification/gas turbine project. In-depth Departmental review of the proposal determined that the project was a unique and innovative concept which would be of significant benefit to the Department's mission. Based on this determination, and in response to the language previously referenced, the Department undertook the FERCO/Vermont Gasification Project through a non-competitive award.

Q69. Please provide a listing of the recipients of (i) the $1,501,000 in funding in FY 1995, and (ii) the $1,760,000 in FY 1996 funding for Municipal Solid Waste, including the funding for each recipient.

A69. FY 1995: recipients were National Renewable Energy Laboratory, Pinnacle Biotechnologies International, Inc., Biochemical Resources, Inc., Solid Waste Association of North America (SWANA).

FY 1996: recipients were the same as FY 1995 with the exception of SWANA, which received no funding.

Q70. For each recipient of Municipal Solid Waste funds identified in the response to question 69 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1996.

A70. The level of project cost-share is provided in the following table which reflects the Energy & Water appropriation for Municipal Sold Waste:

Municipal Sold Waste Funding Recipient Cost-Sharing

Recipient	FY 95	FY 96
National Renewable Energy Laboratory	$0	$0
Pinnacle Biotechnologies International, Inc.	$0	$0
Bioengineering Resources, Inc.	$0	$303,192
Solid Waste Association of North America	$80,000	$0
TOTAL	**$80,000**	**$303,192**

Q71. For those Municipal Solid Waste funding recipients identified in the response to question 69 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A71. The identification and justification is provided in the following table which reflects the Energy & Water appropriation for municipal solid waste:

Recipient	Justification
National Renewable Energy Laboratory	Unique technical and management expertise in municipal solid waste technologies.
Pinnacle Biotechnologies International, Inc.	Prior work experience and discoveries gives the principals exclusive capabilities in the research of converting waste materials by biological processes to clean fuels.
Solid Waste Association of North America	Landfill subcommittee of this non-profit trade association provides unique oversight capabilities.

Q72. On page 518 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Evaluation of the digester will be completed using prior year funding." Please identify the amount prior year funding that will be used.

A72. The amount of prior year funds that will be used is $1,330,000.

Q73. Please provide a listing of the recipients of (i) the $4,950,000 in funding in FY 1995, (ii) the $5,000,000 in FY 1996 funding, and (iii) the requested level of $6,050,000 in FY 1997 for Biofuels–Transportation Feedstock Development, including the funding for each recipient.

A73. The following table provides the information requested:

Biomass Power R&D–Transportation Feedstock Development Funding Recipients
(In Thousands of $)

No.	Major Recipient	FY 95	FY 96	FY 97
1	Oak Ridge National Laboratory (ORNL)	2,730	2,876	TBD
2	Alabama A&M University	93	94	TBD
3	Auburn University	85	84	TBD
4	Colorado State University	30	5	TBD
5	Iowa State University	147	183	TBD
6	Mississippi State University	190	118	TBD
7	National Audubon Society	34	34	TBD
8	National Council for Air & Stream Improvement	38	11	TBD
9	Oklahoma State University	82	82	TBD
10	Oregon State University	50	40	TBD
11	Southern Illinois University	55	40	TBD
12	State University of New York	30	40	TBD
13	Texas A&M University	85	84	TBD
14	USDA-North Central Forest Experiment Station	291	293	TBD
15	USDA-Agriculture Research Service	115	95	TBD
16	University of Minnesota	235	226	TBD
17	University of Tennessee	60	64	TBD
18	University of Washington	49	204	TBD
	TOTAL	**4,399**	**4,573**	**TBD**

Q74. For each recipient of Biofuels–Transportation Feedstock Development funds identified in the response to question 73 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A74. The following table provides the information requested:

Biomass Power R&D–Transportation Feedstock Development
Funding Recipient Cost-Share
(In Thousands of $)

No.	**Major Recipient**	**FY 95**	**FY 96**	**FY 97**	**Competitive**
1	Oak Ridge National Laboratory (ORNL)	200	225	TBD	No
2	Alabama A&M University	175	175	TBD	No
3	Auburn University	22	22	TBD	Yes
4	Colorado State University	0	0	0	No
5	Iowa State University	79	60	TBD	No

No.	Major Recipient	FY 95	FY 96	FY 97	Competitive
6	Mississippi State University	58	25	TBD	Yes
7	National Audubon Society	10	0	0	No
8	National Council for Air & Stream Improvement	0	0	0	No
9	Oklahoma State University	40	40	TBD	Yes
10	Oregon State University	335	268	TBD	Yes
11	Southern Illinois University	0	0	0	
12	State University of New York	275	460	TBD	No
13	Texas A&M University	45	45	TBD	Yes
14	USDA-North Central Experiment Station	207	212	TBD	No
15	USDA-Agriculture Research Service	n/a*	0	0	No
16	University of Minnesota	0	0	0	No
17	University of Tennessee	0	0	0	Yes
18	University of Washington	147	161	TBD	No
19	WesMin Resource Conservation & Development District	290	160	TBD	No
20	University of Georgia	n/a*	0	0	No
21	Virginia Tech	17	17	TBD	Yes
	TOTAL	1,900	1,870	TBD	

n/a*: Not applicable, i.e., recipient did not receive funding.

Q75. For those Biofuels–Transportation Feedstock Development funding recipients identified in the response to question 73 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A75. See the answer to question 74 for recipients receiving non-competitive awards. The justification for the Oak Ridge National Laboratory (No. 1) is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. University awards (Nos. 2, 3, 4, 5, 10, 12, 16 and 20) were based on unsolicited proposals; the sole source justification was based on unique capabilities. Awards to the U.S. Department of Agriculture (Nos. 14 and 15) were based on an Interagency Agreement, taking advantage of USDA's long history, expertise, and experience in silviculture and agriculture to perform specific research required by the program. The University of Washington (No. 18) was a follow-on to a competitive award. WesMin RC&DD (No. 19) was based on a unique State and Federal collaboration and is a highly leveraged project.

Q76. Please provide a listing of the recipients of (i) the $22,435,000 in funding in FY 1995, (ii) the $19,610,000 in FY 1996 funding, and (iii) the requested level of $32,490,000 in FY 1997 for Biofuels–Transportation Biochemical Conversion, including the funding for each recipient.

A76. The following table provides the information requested:

Biomass Power R&D–Transportation Biochemical Conversion Funding Recipients
(In Thousands of $)

No.	Major Recipient	FY 95	FY 96	FY 97
1	National Renewable Energy Laboratory	11,247	12,059	TBD
2	Masada Corporation	450	50	TBD

No.	Major Recipient	FY 95	FY 96	FY 97
3	American Coalition on Ethanol	115	0	0
4	Auburn University	104	50	TBD
5	Cornell University	90	82	TBD
6	Dartmouth College	276	0	0
7	DynCorp	375	0	TBD
8	Ecobalance	50	50	TBD
9	Stone and Webster/Gridley	1,650	200	TBD
10	Hauser Chemical Research Corp.	298	167	TBD
11	Hazen Research Inc.	154	150	TBD
12	Hawaii Natural Energy Inst.	192	0	0
13	Illinois Energy Office	221	0	0
14	Information Resources Inc.	150	35	TBD
15	Independence Biofuels Inc.	100	0	0
16	Nebraska Energy Office	75	0	0
17	Ohio State University	125	0	0
18	Oregon State University	99	0	0
19	Purdue University	119	0	0
20	Royball Engineering	781	TBD	TBD
21	Tennessee Valley Authority	82	0	0
22	Texas A&M	100	0	0
23	TMS	151	225	TBD
24	TSS Consultants	71	0	0
25	UC/Davis	50	0	0
26	University of Toronto	100	80	TBD
27	University of Wisconsin	105	92	TBD
28	Virginia Polytechnic Inst.	108	0	0
29	Washington State Energy Office	35	0	0
30	Colorado School of Mines	0	50	TBD
31	International Energy Agency/Bioenergy	0	160	TBD
32	Ram Mechanical	0	200	TBD
33	TBD-Partnerships	0	0	12,000
	TOTAL	**17,473**	**TBD**	**TBD**

Q77. For each recipient of Biofuels–Transportation Biochemical Conversion funds identified in the response to question 76 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A77. The following table provides the information requested:

Biomass Power R&D–Transportation Biochemical Conversion
Funding Recipient Cost-Share
(In Thousands of $)

No.	Major Recipient	FY 95	FY 96	FY 97	Competitive
1	National Renewable Energy Laboratory	400	465	TBD	No
2	Masada Corporation	585	65	TBD	Yes
3	American Coalition on Ethanol	0	n/a*	n/a*	No
4	Auburn University	0	0	0	Yes
5	Cornell University	0	0	0	No
6	Dartmouth College	0	0	0	Yes
7	DynCorp	0	0	0	No
8	Ecobalance	0	0	0	No
9	Stone and Webster/Gridley	420	40	TBD	No

No.	Major Recipient	FY 95	FY 96	FY 97	Competitive
10	Hauser Chemical Research Corp.	0	0	0	Yes
11	Hazen Research Inc.	0	0	0	Yes
12	Hawaii Natural Energy Inst.	0	0	0	Yes
13	Illinois Energy Office	221	n/a*	n/a*	Yes
14	Information Resources Inc.	0	0	0	Yes
15	Independence Biofuels Inc.	0	0	0	No
16	Nebraska Energy Office	75	n/a*	n/a*	Yes
17	Ohio State University	0	n/a*	n/a*	No
18	Oregon State University	0	n/a*	n/a*	No
19	Purdue University	0	n/a*	n/a*	No
20	Royball Engineering	0	n/a*	0	No
21	Tennessee Valley Authority	0	n/a*	n/a*	No
22	Texas A&M	0	n/a*	n/a*	Yes
23	TMS	0	0	0	No
24	TSS Consultants	0	n/a*	n/a*	No
25	UC/Davis	0	n/a*	n/a*	No
26	University of Toronto	0	0	0	Yes
27	University of Wisconsin	0	0	0	Yes
28	Virginia Polytechnic Inst.	0	0	0	Yes
29	Washington State Energy Office	35	n/a*	n/a*	Yes
30	Colorado School of Mines	n/a*	0	0	No
31	International Energy Agency/ Bioenergy	n/a*	1,000	TBD	No
32	Ram Mechanical	n/a*	0	0	No
33	TBD-Partnerships	n/a*	n/a*	12,000	Yes
	TOTAL	1,736	1,570	TBD	

n/a*: Not applicable, i.e., recipient did not receive funding.

Q78. For those Biofuels–Transportation Biochemical Conversion funding recipients identified in the response to question 76 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A78. See the answer to question 77. The justification for non-competitive funding to the National Renewable Energy Laboratory (No. 1) is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Sole-source justifications for recipient numbers 3, 8, 9,17, 18, 21, 24,25, 30, and 32 are based on unique research capabilities. Non-competitive awards to recipient numbers 5, 15, and 19 are based on research innovation. Awards to recipient numbers 7, 20, and 23 are justified on the basis of unique expertise and capability to provide technical and analytical support for the program. The International Energy Agency/Bioenergy award (No. 31) is a cost-shared agreement with other member countries, offering the opportunity to collaborate in areas of common interest.

Q79. Please provide a listing of the recipients of (i) the $4,515,000 in funding in FY 1995, and (ii) the $1,775,000 in FY 1996 funding for Biofuels–Transportation Thermochemical Conversion, including the funding for each recipient.

A79. The following table provides the information requested:

Biofuels–Transportation Thermochemical Conversion Funding Recipients
(In Thousands of $)

Major Recipient	FY 95	FY 96
NREL	2,970	$1,775*
DynCorp/Meridian	555	0
Hazen Research Inc.	67	0
Hawaii Natural Energy	192	0
University of Utah	135	0
TOTAL	3,919	1,755

*FY 1996 funding used to closeout activities.

Q80. For each recipient of Biofuels–Transportation Thermochemical Conversion funds identified in the response to question 79 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 18995-FY 1997.

A80. There was no cost-sharing for Biofuels–Transportation Thermochemical Conversion in FY 1995. FY 1996 funding is being used to terminate activities in this area.

Q81. For those Biofuels–Transportation Thermochemical Conversion funding recipients identified in the response to question 79 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A81. See the answer to question 79. The justification for the National Renewable Energy Laboratory (no. 1) is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Non-competitive awards to recipient numbers 2 and 3 are based on unique capabilities. The award to the University of Utah (No. 5) is based in innovative research.

Q82. Please provide a listing of the recipients of (i) the $4,742,000 in funding in FY 1995, (ii) the $3,811,000 in FY 1996 funding, and (iii) the requested level of $2,000,000 in FY 1997 for the Regional Biomass Energy Program, including the funding for each recipient.

A82. The following table provides the information requested:

Regional Biomass Energy Program Funding Recipients
(In Thousands of $)

No.	Major Recipient	FY 95	FY 96	FY 97
1	University of Idaho	220	140	TBD
2	Montana Department of Environmental Quality	291	TBD	TBD
3	Craven Farms, Inc.	78	TBD	TBD
4	Western Environmental Engineers	75	TBD	TBD
5	Northwest Fuel Development Corp., Inc.	100	TBD	TBD
6	Kootenai Tribe of Idaho	100	TBD	TBD
7	Alaska Department of Community and Regional Affairs, Energy Division	105	TBD	TBD
8	Montana Department of Environmental Quality	80	TBD	TBD

No.	Major Recipient	FY 95	FY 96	FY 97
9	Idaho Department of Water Resources	130	TBD	TBD
10	Oregon Department of Energy	86	TBD	TBD
11	Washington State Energy Office	67	TBD	TBD
12	Ethanol Producers and Consumers	140	TBD	TBD
13	Antares Group	75	TBD	TBD
14	EUA/Citizens Conservation Services	50	TBD	TBD
15	C.T. Donovan & Associates	25	TBD	TBD
16	University of Wisconsin-Madison	75	TBD	TBD
17	Triad Engineering, Inc.	75	TBD	TBD
18	Mankato State University	50	TBD	TBD
19	Purdue University	60	TBD	TBD
20	Illinois Department of Commerce and Community Affairs	40	40	TBD
21	Indiana Department of Commerce	40	40	TBD
22	Iowa Department of Natural Resources	40	40	TBD
23	Michigan Public Service Commission	40	40	TBD
24	Minnesota Department of Public Service	40	40	TBD
25	Public Utilities Commission of Ohio	40	40	TBD
26	Wisconsin Energy Bureau	40	40	TBD
27	Western Area Power Administration	124	155	TBD
28	Kansas State University	125	TBD	TBD
29	Oklahoma State University	60	TBD	TBD
30	California Energy Commission	50	TBD	TBD
31	Electric Power Research Institute	50	TBD	TBD
32	Utah Energy Division	50	50	TBD
33	Yolo County, California	0	50	TBD
34	Nevada State Energy Office	0	33	TBD
35	California Polytechnic Inst.	0	50	TBD
36	New Mexico State University	0	42	TBD
37	Montezuma County, Colorado	0	48	TBD
38	University of Arizona	0	47	TBD
39	Kansas Electric Cooperative	0	50	TBD
	TOTAL	2,621	TBD	TBD

Q83. For each recipient of Regional Biomass Energy Program funds identified in the response to question 82 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A83. The following table provides the information requested:

Regional Biomass Energy Program Funding Recipient Cost-Share
(In Thousands of $)

No.	Major Recipient	FY 95	FY 96	FY 97	Competitive
1	University of Idaho	267	TBD	TBD	No
2	Montana Department of Environmental Quality	408	TBD	TBD	Yes
3	Craven Farms, Inc.	78	TBD	TBD	Yes
4	Western Environmental Engineers	235	TBD	TBD	Yes
5	Northwest Fuel Development Corp., Inc.	117	TBD	TBD	Yes
6	Kootenai Tribe of Idaho	200	TBD	TBD	Yes
7	Alaska Department of Community and Regional Affairs, Energy Division	128	TBD	TBD	No
8	Montana Department of Environmental Quality	27	TBD	TBD	No
9	Idaho Department of Water Resources	87	TBD	TBD	No

No.	Major Recipient	FY 95	FY 96	FY 97	Competitive
10	Oregon Department of Energy	51	TBD	TBD	No
11	Washington State Energy Office	25	TBD	TBD	No
12	Ethanol Producers and Consumers	146	TBD	TBD	Yes
13	Antares Group	100	TBD	TBD	Yes
14	EUA/Citizens Conservation Services	0	0	0	No
15	C.T. Donovan & Associates	100	TBD	TBD	Yes
16	University of Wisconsin-Madison	105	TBD	TBD	Yes
17	Triad Engineering, Inc.	83	TBD	TBD	Yes
18	Mankato State University	50	TBD	TBD	Yes
19	Purdue University	64	TBD	TBD	Yes
20	Illinois Department of Commerce and Community Affairs	200	40	TBD	No
21	Indiana Department of Commerce	20	20	TBD	No
22	Iowa Department of Natural Resources	20	20	TBD	No
23	Michigan Public Service Commission	20	20	TBD	No
24	Minnesota Department of Public Service	20	20	TBD	No
25	Public Utilities Commission of Ohio	20	20	TBD	No
26	Wisconsin Energy Bureau	20	20	TBD	No
27	Western Area Power Administration	0	0	0	No
28	Kansas State University	0	0	0	No
29	Oklahoma State University	60	TBD	TBD	No
30	California Energy Commission	150	TBD	TBD	No
31	Electric Power Research Institute	25	TBD	TBD	No
32	Utah Energy Division	50	53	TBD	Yes
33	Yolo County, California	n/a*	50	TBD	Yes
34	Nevada State Energy Office	n/a*	50	TBD	Yes
35	California Polytechnic Inst.	n/a*	95	TBD	Yes
36	New Mexico State University	n/a*	50	TBD	Yes
37	Montezuma County, Colorado	n/a*	30	TBD	Yes
38	University of Arizona	n/a*	57	TBD	Yes
39	Kansas Electric Cooperative	n/a*	162	TBD	Yes
	TOTAL	**2,876**	**TBD**	**TBD**	

n/a*-non applicable, i.e., recipient did not receive funding.

Q84. For those Regional Biomass Energy Program funding recipients identified in the response to question 82 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A84. See the answer to question 83. The justification for non-competitive awards to recipient numbers 1, 14, 27, 28, 29, and 30 is based on unique or special capabilities. The justification for recipient numbers 7, 8, 9, 10, and 11 is based on the States' specific expertise in a particular biomass area. Grants were awarded to recipient numbers 20 through 26 based on a solicitation limited to State Energy Offices in the Great Lakes Region.

Wind Energy Systems

Q85. Page 523 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for Wind Energy Systems at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.05 Q**	**0.28 Q**	**1.45 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$376 M**	**$1.19 M**	**$10.142 M**
Carbon Equivalent Emissions Reductions	**1.19 MMT**	**5.84 MMT**	**28.51 MMT**

Q85a. Please provide detailed documentation of these claimed benefits.

A85a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity from wind which were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1995. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q85b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A85b. The benefits cited are based on past and expected future technology improvements resulting from DOE support of R&D conducted by the National Laboratories and U.S. industry. The DOE supported research addresses the most critical technical and customer-acceptance issues in Wind. We cannot state with certainty that all private research efforts would cease without the Federal program, but we do know that the Federally funded research has been the principal catalyst in fostering industry interest in Wind research. Without the advances resulting from DOE and industry R&D, the benefits cited would not be realized. What is more certain is that much of what remains of a U.S. market for wind would be lost to the Europeans and the Japanese, who present strong competition to the U.S. wind industry today.

Q86. On page 523 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Wind energy generating capacity installed in the U.S. currently totals over 1700 MW, is expected to grow to 3700 MW by 2000, and reach 10,000 MW by 2010." Please provide documentation for the estimates. Also, please compare these estimates with the wind estimates contained in the EIA's *Annual Energy Outlook 1996*, and explain any differences.

A86. Our estimate of 1700 MW installed in the United States is based on wind project data compiled by the California Energy Commission supplemented by known data about wind projects outside California. Our data is consistent with the American Wind Energy Association. The capacity additions projected for the year 2000 are internal wind program projections based on the Quality Metrics activity, as well as announced wind projects. The projection for the year 2010 is an internal program estimate that is lower than that projected by the Quality Metrics activity because of the effect of utility restructuring.

The Energy Information Administration shows 2,090 MW installed for 1995, this is a 310 MW increase from the year before of 1,780 MW. We do not understand the 310 MW increase for 1995. EIA's 1994 figure is much closer to what we believe is the actual number. Under conservative assumptions about the installed capital cost of wind, the Energy Information Administration projects about 650 NW added by the year 2000. another 800 MW added by 2005, and 1600 MW by 2010. We attribute the differences in projections to the relatively conservative nature of the cost/performance projections for wind technology assumed by EIA.

Q87. Please describe the "Kotzebue, Alaska wind project" (page 527 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), its progress and cost to date, expected date and cost of completion, and expected results at completion.

A87. The State of Alaska and Kotzebue Electric Association wind project proposal was selected under the Sustainable Technology Energy Partnerships solicitation from the National Renewable Energy Laboratory in 1995. The objective of the project is to demonstrate how wind plants can be installed, operated, and maintained in the high latitude village power environment and to transfer that experience to other villages in Alaska. Project planning is well-under way. Three Atlantic Orient 50 kW 15/50 wind turbines will be shipped this summer to Alaska for installation at Kotzebue in the fall. Wind turbine installation and operation experience, performance data and utility load and power quality data will be collected and reported for two years. NREL and the State of Alaska are currently negotiating a contract, so no Federal government costs on the contract have been incurred to date. Negotiations are expected to be complete in 2 to 3 months. Upon completion, the project will verify the cost and performance of operating wind turbines, reduce dependence on high cost diesel fuel, and provide an experience that will be transferred to villages throughout the arctic environment.

Q88. Please provide a listing of the recipients of (i) the $8,000,000 in funding in FY 1995, (ii) the $9,900,000 in FY 1996 funding, and (iii) the requested level of $15,200,000 in FY 1997 for Wind Applied Research, including the funding for each recipient.

A88. The listing is provided as a table below in which the funding is in millions of dollars:

Wind Energy Applied Research Funding Recipients
(In Millions of $)

Recipient	FY 95	FY 96	FY 97
NREL In-house	3.23	5.51	9.08
Sandia In-house	1.04	1.85	1.85
Contracts			
University of Utah	0.16	0.12	

Recipient	FY 95	FY 96	FY 97
University of Texas at El Paso	0.1	TBD	
Mechanical Dynamics, Inc.	0.11	0.0	
Blade Solicitation-TBD	0.2	0.0	
Montana State	0.26	0.2	
Colorado University	0.21	0.12	
HBCU-TBD	0.0	0.2	
University of New Mexico	0.12	0.14	
University Solicitation-TBD	0.0	0.2	
Stanford University	0.25	0.22	
Wichita State University	0.15	0.0	
Tennessee State University-HBCU	0.34	0.0	
Misc. Capital Equipment	1.0	0.78	
TBD	0.0	0.0	4.28
TOTAL	**7.17**	**TBD**	**15.21**

Q89. For each recipient of Wind Applied Research funds identified in the response to question 88 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A89. The Applied Research area includes activities that support the wind industry through the development of computer codes and design techniques. Much of this is performed in the National Laboratories or through universities and other experts. Consequently, there is little or no cost-sharing associated with the performers identified above.

Q90. For those Wind Applied Research funding recipients identified in the response to question 88 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A90. Laboratory funding is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Non-competitive subcontract awards result from continuation of activities previously funded competitively, while others are awarded on the basis of unique expertise or exclusive capabilities. These non-competitive awards include Mechanical Dynamics, Inc., the University of California, and Southwest Technology Development Institute at the University of New Mexico.

Q91. Please provide a listing of the recipients of (i) the $14,810,000 in funding in FY 1995, (ii) the $15,320,000 in FY 1996 funding, and (iii) the requested level of $19,700,000 in FY 1997 for Wind Turbine Research, including the funding for each recipient.

A91. The listing is provided as a table below in which the funding is in millions of dollars:

Wind Turbine Research Funding Recipients
(In Millions of $)

Recipient	FY 95	FY 96	FY 97
NREL In-house	4.15	2.3	6.5
Sandia In-house	0.95	0.3	0.5
Contracts			
Atlantic Orient Corp.	0.06	0.0	

Recipient	FY 95	FY 96	FY 97
R. Lynette and Assoc.	0.95	0.0	
New World Power Technology Corp.	0.94	0.0	
Ohio State University	0.16	0.0	
Next Generation Turbine Project (TBD)*	6.9	5.6	9.3
Blade Manufacturing Project, (TBD) *	0.45	0.50	1.0
Small Wind Turbine Project, (TBD) **	0.0	0.0	1.0
Other	0.25	0.1	
To be determined (TBD)	0.0	6.52	1.4
TOTAL	14.81	15.32	19.7

*Competitive solicitation underway; amounts subject to negotiations. Contract awards expected 6/96-9/96.
**Competitive solicitation beginning 6/96. Contract awards expected 3/97.

Q92. For each recipient of Wind Turbine Research funds identified in the response to question 91 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A92. Cost-sharing for FY 1996 and FY 1997 remains to be determined. Major cost-sharing for FY 1995 is subject to contract negotiations now underway. The cost-sharing goal for the next generation turbine development program is 50 percent, with a minimum of 30 percent. The minimum cost-share for the blade manufacturing project is 25 percent. Negotiated cost-sharing for the near term turbine prototype testing is $0.54 million.

Q93. For those Wind Turbine Research funding recipients identified in the response to question 91 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A93. All projects and participants identified in question 91 were selected on a competitive basis, with the exception of Ohio State University which has unique capabilities in airfoil testing. Laboratory funding is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q94. Please provide a listing of the recipients of (i) the $7,715,000 in funding in FY 1995, (ii) the $6,331,000 in FY 1996 funding, and (iii) the requested level of $8,201,000 in FY 1997 for Wind Cooperative Research and Testing, including the funding for each recipient.

A94. The recipients and funding are identified in the table below in which the funding is in millions of dollars:

Wind Cooperative Research and Testing Funding Recipients
(In Millions of $)

Recipient	FY 95	FY 96	FY 97
NREL In-house	4.28	4.0	4.9
Sandia In-house	0.15	0.1	0.2
Contracts			
Electrotek	0.30	0.1	
American Wind Energy Assoc.	0.77	0.6	
Princeton Economic Research, Inc. (PERI)	0.35	0.3	

Recipient	FY 95	FY 96	FY 97
New World Power Corp.	0.9	0.0	
Utility Wind Interest Group	0.4	0.0	
Boise State	0.06	0.04	
UC Santa Cruz	0.3	0.24	
Misc. consultants	0.65	0.77	
Other	0.15	0.75	
To be determined (TBD)	0.0	0.0	3.1
TOTAL	8.31	6.90	6.2

Q95. For each recipient of Wind Cooperative Research and Testing funds identified in the response to question 94 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A95. The Utility Wind Interest Group coordinates and manages the Utility Wind Resource Assessment program in which the seven participating utility teams are providing 65 percent of total project funding. The utility share amounts to $600,000. In addition, Kenetech is providing $200,000 of in-kind cost-sharing in CRADAs with NREL and Sandia, and Zond Systems is providing $100,000 in blades for fatigue testing at the National Wind Technology Center.

Q96. For those Wind Cooperative Research and Testing funding recipients identified in the response to question 94 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A96. Projects in the Wind Cooperative Research and Testing category that have been awarded on a non-competitive basis due to unique expertise or exclusive capabilities include Electrotek Concepts, Inc., the American Wind Energy Association, Princeton Economic Research, Inc., and the University of California at Santa Cruz. Laboratory funding is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q97. Please provide a listing of the recipients of (i) the $14,506,000 in funding in FY 1995, and (ii) the $6,549,000 in FY 1997 funding for Wind Technology Development, including the funding for each recipient.

A97. The information is provided in a table below in which the funding is in millions of dollars:

Wind Technology Development Funding Recipients
(In Millions of $)

Recipient	FY 95	FY 97
NREL In-house	0.6	0.0
Contracts		
Sustainable Technology Energy Partnerships (STEP)		
California Energy Commission	0.25	
Nebraska Energy Office	0.08	
Minnesota Department of Public Service	0.05	
New Mexico Energy, Min, and Nat. Res.	0.02	
State of Vermont	0.02	
TBD	1.22	
Turbine Verification Program-EPRI	3.0	
Technology Deployment Project-Competitive Solicitation-TBD	5.94	
TBD		6.5
TOTAL	11.18	6.5

Q98. **For each recipient of Wind Technology Development funds identified in the response to question 97 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 and FY 1997.**

A98. The information is provided in a table below in which the funding is in millions of dollars:

Wind Technology Development Funding Recipient Cost-Sharing
(In Millions of $)

Recipient	FY 95	FY 97
Contracts		
Sustainable Technology Energy Partnerships (STEP)	Target 50%	TBD
California Energy Commission	0.26	
Nebraska Energy Office	0.08	
Minnesota Department of Public Service	0.05	
New Mexico Energy, Min, and Nat. Res.	0.02	
State of Vermont	0.02	
Turbine Verification Program-EPRI	17.0	TBD
Technology Deployment Project, minimum 80 private sector goal	TBD	TBD

Q99. **For those Wind Technology Development funding recipients identified in the response to question 97 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.**

A99. Under this activity, all external participants were competitively determined except the Electric Power Research Institute (EPRI). EPRI, in turn, added funding to the pool of resources available for the project and managed a competitive solicitation. Laboratory funding is based on a determination by project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Renewable Energy Production Incentive (REPI) Program

Q100. Page 530 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Renewable Energy Production Incentive (REPI) Program at the proposed funding levels:

	2000	2005
Annual Primary Energy Displaced	**0.007 Q**	**0.013 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$46 M**	**$88 M**
Carbon Equivalent Emissions Reductions	**0.14 MMT**	**0.26 MMT**

Q100a. Please provide detailed documentation of these claimed benefits.

A100a. The energy displacements of 0.007Q and 0.013Q equate to approximately 2 billion and 4 billion kilowatt-hours, respectively. This is the annual energy that would be produced by electric generating capacities of 500 megawatts and 1,000 megawatts. These installed capacity figures are the estimated aggregated levels of solar, wind, geothermal, and biomass generating facilities qualifying for REPI in 2000 and 2005. The values for displaced electricity and carbon emissions are a straightforward calculation based in the energy displacement estimates.

Q100b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A100b. There can be no certainty that the installations would not occur in the absence of DOE funding. However, in nearly every case for current REPI participants, the facility owner contacted DOE prior to proceeding with a project to inquire about the REPI program and qualification requirements. We believe this indicates strong likelihood that REPI has been a factor in decision making regarding projects to date. It is our expectation that this program influence will continue.

Q101. What is the rate of payment for energy produced by qualified renewable energy facilities?

A101. The law establishing the REPI program specifies a Fiscal Year 1994 payment of 1.5 cents/kilowatt-hour for qualified energy output and requires adjustment for inflation in years following. The inflation adjustment is based on official figures published by OMB 3 or 4 months after the close of any given Fiscal Year. The payment rate in Fiscal Year 1995 was 1.5315789 cents/kilowatt-hour and in Fiscal Year 1996 is 1.571637 cents/kilowatt-hour.

Q102. What is the definition of a "qualified renewable energy facility"?

A102. A qualified facility is 1) based on solar, wind, geothermal, or biomass energy sources; 2) owned by a State or subdivision of a State or non-profit membership owned cooperative; and 3) in operation after October 1, 1993 and before September 30, 2003.

Q103. Please provide a listing of the recipients of (i) the $4,659,000 in funding in FY 1995, (ii) the $662,000 in FY 1996 funding, and (iii) the requested level of $3,489,000 in FY 1997 for the REPI program, including the funding for each recipient.

A103i and A103(ii). The recipients of Fiscal Years 1995 and 1996 made under the REPI program are as follows:

REPI Funding Recipients

Recipient	FY 95	FY 96
Sacramento Municipal Utility District (SMUD)	$100,725	$216,814
City of Glendale, California	$176,260	$946,921
Lycoming County, Pennsylvania	$100,793	$138,792
Emerald Peoples' Utility District, Oregon	$167,290	$189,686
University of California, Los Angeles (UCLA)	$148,052	$875,637
Pacific Northwest Generating Cooperative (PNGC)	$0	$15,325
Waverly Light and Power	$0	$3,441
TOTAL	$693,120	$2,386,616

A103iii. Fiscal Year 1997 payments will depend on the number of applicants and their actual net electric production during Fiscal Year 1996.

Q104. For those REPI funding recipients identified in the response to question 103 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A104. All REPI funds were awarded on a non-competitive basis. Each recipient received payment after making application to DOE and meeting the qualifications and requirements specified in the Department's rule published on July 19, 1995.

Q105. Please provide a listing of all applicants for REPI program funding in each of FY 1995 - FY 1997.

A105. The above tables comprise the listing of all REPI applicants inasmuch as all applicants to date have received payment. None has been denied.

Resource Assessment

Q106. Please provide a listing of the recipients of (i) the $3,847,000 in funding in FY 1995, and (ii) the $1,942,000 in FY 1996 funding for Resource Assessment, including the funding for each recipient.

A106. The recipients are provided in the following table.

Resource Assessment Funding Recipients
(In Thousands of $)

Recipient	FY 95	FY 96
National Renewable Energy Laboratory	2,612	1,516
SUNY/Albany	145	0
Other (includes multiple universities, private companies and consultants)	509	179
TOTAL	3,266	1,695

Q107. For each recipient of Resource Assessment funds identified in the response to question 106 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 and FY 1996.

A107. The SUNY/Albany provided $130,00 [sic] in cost-sharing in FY 1995.

Q108. For those Resource Assessment funding recipients identified in the response to question 106 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A108. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q109. On page 534 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Program close out initiated with prior year funds." Please identify the amount prior year funds that will be used.

A109. Of the $300,000 identified for program closeout, $150,000 represents FY95 funds and $150,000 represents FY96 funds.

Solar and Renewable Energy Deployment

Q110. Page 536 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the "Commercialization Ventures" portion of the Solar and Renewable Energy Deployment programs at the proposed funding levels:

	1997	2000	2005	2010
Total Primary Energy Displaced (million MMBtu)	3.7	8.5	30.4	62.2
Carbon Equivalent Emissions Reductions ('000tons)	7.9	13.6	33.2	59.2

Q110a. Please provide detailed documentation of these claimed benefits.

A110a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration of the technologies receiving assistance under the program. These projections are based on information provided by the applicants and on the costs of electricity for these technologies. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q110b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A110b. The benefits cited are based on past and expected future technology sales resulting from DOE support of emerging renewable energy technologies. We cannot state with certainty that the private efforts toward commercialization of these technologies would cease without the Federal program, but we do know that in many cases the Federal funding was cited as an integral part of the projects. In fact, expressed need for Federal involvement is a legislatively mandated part of the evaluation criteria.

Q111. On page 536 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Using FY 2000 funding, the Solar International programs will generate $82 million in cumulative exports and $20 million in Federal Tax revenues."

Q111a. What is "FY 2000 funding"?

A111a. In this instance, "FY 2000 funding" will be those funds that are appropriated in Fiscal Year 2000 to the Solar International programs, assumed to be $4 million. The benefits cited are those that will accrue in that year and out years as a likely result of activities supported by those funds.

Q111b. Please document the claim of "$82 million in cumulative exports and $20 million in Federal Tax revenues."

A111b. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The direct measurement of the benefits of commercialization efforts is difficult due to the time lag between the initial Federal effort and actual sales or exports. However, estimates of sales were derived from work being done at the Department of Commerce and the California Energy Commission. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q112. Please provide a listing of the recipients of (i) the $8,953,000 in funding in FY 1995, (ii) the $3,886,000 in FY 1996 funding, and (iii) the requested level of $6,149,000 in FY 1997 for Solar International, including the funding for each recipient.

A112. The requested information is provided in the following table:

Recipient	FY 1995	FY 1996	FY 1997
Center for Clean Air Policy	$391,000	$250,000	
International Fund for Renewable Energy and Energy Efficiency	783,250	275,000	
Los Alamos National Laboratory	100,000	0	
Lawrence Berkeley National Laboratory	400,000	250,000	
Pacific Northwest National Laboratory	206,750	125,000	
US Export Council for Renewable Energy	1,059,000	1,075,000	
National Renewable Energy Laboratory	1,553,000	361,000	
Sandia National Laboratories	997,000	125,000	
Edison Electric Institute	0	650,000	
CAMBER, Corp.	609,000	75,000	
TBD	0	0	$6,149,000
Total	**$6,099,000**	**$3,186,000**	**$6,149,000**

Q113. For each recipient of Solar International funds identified in the response to question 112 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A113. The contracts awarded by the Solar International program did not incorporate provisions for cost-sharing.

Q114. For those Solar International funding recipients identified in the response to question 112 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A114. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Funding to other organizations on a non-competitive basis, including the Export Council for Renewable Energy, Edison Electric Institute, International Fund for Renewable Energy and Energy Efficiency and the Center for Clear Air Policy is also based on a determination by DOE project managers that their staff are uniquely qualified and have exclusive capabilities to accomplish work assignments.

Q115. Please provide a listing of the recipients of (i) the $11,163,000 in funding in FY 1995, (ii) the $2,840,000 in FY 1996 funding, and (iii) the requested level of $1,000,000 in FY 1997 for Commercialization Ventures, including the funding for each recipient.

A115. The requested information is provided in the following table:

Recipient	FY 1995	FY 1996	FY 1997
NEOS Corporation	$200,000		
ABB Combustion Engineering, Inc.	3,520,990		
Cummins Power Generation, Inc.	910,970		

Recipient	FY 1995	FY 1996	FY 1997
Oxbow Geothermal Corporation	2,500,000		
CAMBER, Corp.	750,000	250,000	
KPMG Peat Marwick LLP	400,000	1,000,000	
National Renewable Energy Laboratory (For FY 1996 Solicitation)	2,676,040		
Reserved for Project Solicitation	0	1,005,000	
TBD			$1,000,000
Total	$10,958,000	$2,255,000	$1,000,000

Q116. For each recipient of Commercialization Ventures funds identified in the response to question 115 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A116. The requested information is provided in the following table:

Recipient	FY 1995	FY 1996	FY 1997
NEOS Corporation	$200,000		
ABB Combustion Engineering, Inc.	7,570,000		
Cummins Power Generation, Inc.	910,970		
Oxbow Geothermal Corporation	2,773,068		
FY 1996 Solicitation	TBD		
Reserved for Project Solicitation			
TBD			
Total	TBD	TBD	

Q117. For those Commercialization Ventures funding recipients identified in the response to question 115 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A117. FY 1995: There were no non-competitive awards.

Q118. Please provide a listing of the recipients of (i) the $2,153,000 in funding in FY 1995, (ii) the $1,345,000 in FY 1996 funding, and (iii) the requested level of $1,360,000 in FY 1997 for Information and Communications, including the funding for each recipient.

A118. The requested information is provided in the following table:

Recipient	FY 1995	FY 1996	FY 1997
National Renewable Energy Laboratory	$2,153,000	$1,345,000	$1,360,000

Q119. For each recipient of Information and Communications funds identified in the response to question 118 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A119. There was no cost-sharing done with the recipient in FY 1995 - FY 1997.

Q120. For those Information and Communications funding recipients identified in the response to question 118 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A120. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q121. Please provide a listing of the recipients of (i) the $6,600,000 in funding in FY 1995, and (ii) the $6,600,000 in FY 1996 for Tribal Grants, including the funding for each recipient.

A121. The requested information is provided in the following table:

Recipient	FY 1995	FY 1996
Navajo Nation	$6,600,000	$6,100,000
Crow Energy Corporation	0	500,000
Total	**$6,600,000**	**$6,600,000**

Q122. For each recipient of Tribal Grants funds identified in the response to question 121 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 and FY 1996.

A122. The contracts awarded by the Tribal Grants program as directed by the report language for this program did not incorporate provisions for cost-sharing.

Q123. For those Tribal Grant funding recipients identified in the response to question 121 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A123. The funds were awarded non-competitively, based on the direction contained in the language of the House-Senate Appropriations Conference Committee report.

Geothermal

Q124. Page 544 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Geothermal program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.04 Q**	**0.58 Q**	**1.59 Q**
Annual Displaced Electricity Value ($0.08/kWh)	**$350 M**	**$4,130 M**	**$11,235 M**
Carbon Equivalent Emissions Reductions	**1.15 MMT**	**13.71 MMT**	**39.96 MMT**

Q124a. Please provide detailed documentation of these claimed benefits.

A124a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity from geothermal. These projections of the cost electricity from geothermal were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1995. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q124b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A124b. The benefits cited require considerable progress in exploration, drilling, resource management, and energy conversion technologies in order to significantly reduce the risk associated with geothermal projects. Acting alone, industry lacks the resources to make the broad advances across these technological fronts needed to achieve the projected benefits. Without the DOE programs, these advances will not take place within the time frame of the projections, and the benefits would not occur.

Q125. Please provide a listing of the recipients of (i) the $43,837,000 in funding in FY 1995, (ii) the $28,092,000 in FY 1996 funding, and (iii) the requested level of $29,118,000 in FY 1997 for Geothermal Electric R&D and Development, including the funding for each recipient.

A125. The requested information is provided in the following table:

(In Millions of $)

Funding Recipients	FY 1995	FY 1996 (Est.)	FY 1997 (Est.)
Brookhaven National Laboratory	1.7	1.4	1.5
Idaho National Engineering Laboratory	2.4	0.8	0.9
Lawrence Berkeley Laboratory	0.8	0.8	0.9
Lawrence Livermore National Laboratory	0.6	1.0	0.9
Los Alamos National Laboratory	3.4	1.9	1.2
National Renewable Energy Laboratory	1.1	0.7	0.8
Oak Ridge National Laboratory	0.5	0.5	0.6
Sandia National Laboratories	6.4	3.5	4.9
Energy Technology Engineering Center	8.1	0.0	
National Advanced Drilling & Excavation Tech Inst.	1.3	1.3	
Oregon Institute of Technology	0.3	0.3	
Stanford University	0.4	0.4	
University of California at San Diego	0.3	0.3	
University of Utah	1.3	1.3	
Unocal Geothermal	0.5	0.4	
County of Clearlake	1.8	1.7	
City of Santa Rosa	0.0	0.3	
Earth Power Energy & Minerals	0.8	0.0	
Geothermal Resources Council	0.1	0.1	

Funding Recipients	FY 1995	FY 1996 (Est.)	FY 1997 (Est.)
Geothermal Energy Association	0.5	0.4	
Oxbow Geothermal	0.5	0.3	
Exploration Technology Request for Proposals-TBD	1.0	1.0	
Reservoir Technology Request for Proposals	1.0	1.0	
Douglas Energy Co.	0.4	0.0	
Various Universities and Service Companies	1.0	1.0	
Barber-Nichols Inc.	0.3	0.0	
Geothermal Test Facility Contractors	0.6	0.0	
S-Cubed	0.1	0.2	
Princeton Economic Research Inc.	0.9	0.6	
TBD	0.0	0.0	17.4
Total	**38.10**	**21.20**	**29.1**

Q126. For each recipient of Geothermal Electric R&D and Development funds identified in the response to question 125 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A126. The level of funding provided by the recipient as cost-sharing for FY 1995-FY 1997 under the Geothermal Electric R&D and Development funds identified above in the response to Q125 follows.

(In Millions of $)

Funding Recipient Cost-Sharing	FY 1995	FY 1996 (Est.)	FY 1997 (Est.)
Unocal Geothermal	0.7	0.3	TBD
County of Clearlake	7.0	7.0	TBD
Stanford University	0.1	0.1	TBD
University of Utah	0.5	0.5	TBD
Earth Power Energy & Minerals	0.8	3.0	TBD
Geothermal Resources Council	0.3	0.3	TBD
Geothermal Energy Association	0.4	0.4	TBD
Oxbow Geothermal	0.5	0.3	TBD
Exploration Technology Request for Proposals-TBD	TBD	TBD	TBD
Reservoir Technology Request for Proposals	TBD	TBD	TBD
Douglas Energy Co.	0.3	0.0	TBD
Various Universities and Service Companies	0.5	0.5	TBD

Q127. For those Geothermal Electric R&D and Development funding recipients identified in the response to question 125 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A127. National Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Others receiving non-competitive awards include: the National Advanced Drilling and Excavation Technologies Institute, Geothermal Resources Council, and the Geothermal Energy Association. Each of these nonprofit organizations has a unique capability in providing educational or organizational services that are not otherwise available. The Congress has specified funding actions for certain contractors through report language. These include: the County of Clearlake and Oregon Institute of Technology.

Q128. Please provide a listing of the recipients of (i) the $1,600,000 in funding in FY 1995, (ii) the $5,300,000 in FY 1996 funding, and (iii) the requested level of $6,482,000 in FY 1997 for Geothermal Heat Pump Deployment, including the funding for each recipient.

A128. The following table lists the recipients for the Geothermal Heat Pump Program.

(In Millions of $)

Funding Recipients	**FY 1995**	**FY 1996 (Est.)**	**FY 1997 (Est.)**
Sandia National Laboratories	0.65	0.40	0.40
Oak Ridge National Laboratory	0.25	0.20	0.20
Oklahoma State University	0.35	0.35	
Geothermal Heat Pump Consortium	3.53	3.20	
Georgia Institute of Technology	0.15	0.01	
National Rural Electric Cooperative Assoc.	0.0	0.13	
TBD	0.0	0.0	5.88
Total	**4.93**	**4.29**	**6.48**

Q129a. For each recipient of Geothermal Heat Pump Deployment funds identified in the response to question 128 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A129a. Cost-sharing amounts from recipients of Geothermal Heat Pump Deployment funds are provided as follows:

(In Millions of $)

Funding Recipient Cost-Sharing	**FY 1995**	**FY 1996 (Est.)**	**FY 1997 (Est.)**
Oklahoma State University	0.35	0.35	
Geothermal Heat Pump Consortium	2.00	4.92	
National; Rural Electric Cooperative Assoc.	0.0	0.25	
Total	**2.35**	**5.52**	**6.48**

Q129b. Also, please provide the prices of currently available geothermal heat pumps.

A129b. The price of a residential geothermal heat pump is about equal to that of an air-source heat pump plus the additional cost of an in-ground heat exchanger. In competitive markets, the additional cost of the in-ground heat exchanger is about $2,500 for a typical detached dwelling. If a residential geothermal heat pump is financed through the mortgage, the savings in electric power costs usually will more than offset the increased mortgage payments. For commercial buildings, geothermal heat pumps often afford a lower first cost and reduced operating and maintenance cost, compared to conventional systems.

Q130. For those Geothermal Heat Pump Deployment funding recipients identified in the response to question 128 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A130. National Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Others receiving non-competitive awards include: Oklahoma State University, the Geothermal Heat Pump Consortium, Georgia Institute of Technology, and the National Rural Electric Cooperative Association. Each of these nonprofit organizations was selected on the basis of unique qualifications and exclusive capabilities.

Hydrogen Research

Q131. On page 553 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Hydrogen fuel cells are expected to account for 36 GW, a 4.2% share of the projected U.S. total by the year 2020. Between 2016-2020, models project installation of an additional 21 GW of fuel cells, 27% of all new electricity capacity."

Please provide detailed documentation of these estimated fuel cell capacities.

A131. The total U.S. market for new electricity generation capacity, from 1996 to 2020, is projected by the Energy Information Administration (Annual Energy Outlook, 1996) to be 279 GW. Of that total market, hydrogen fuel cells capture 36 GW (or 4.2%), based on the levelized cost of electricity (LCE) projected for hydrogen fuel cells during the same period of time. The LCE is calculated from capital cost, O/M costs, fuel cost, and system efficiency for all competing electricity generation technologies. The Renewable Energy Penetration model is used to project relative market share, as based on the LCE'S.

Q132. Page 553 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Hydrogen Research program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.00 Q**	**0.01 Q**	**1.16 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$7 M**	**$73 M**	**$8,123 M**
Carbon Equivalent Emissions Reductions	**0.02 MMT**	**0.15 MMT**	**17.06 MMT**

Q132a. Please provide detailed documentation of these claimed benefits.

A132a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of electricity from hydrogen technologies. These projections of the cost of electricity from hydrogen were reviewed by industry experts including the Electric Power Research Institute. The cost of competing fuels and other economic assumptions were taken from the Energy Information Administration's Annual Energy Outlook 1995. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q132b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A132b. The benefits cited are based on market penetration of hydrogen fuel cell technologies. Without the DOE programs it is likely that U.S. technology would not have the significant impact projected in the time frame of the benefits estimates given in the table. The Japanese and others are also developing this technology and any contribution to the U.S. electricity supply would likely be from imported technology resulting from the R&D advances of these foreign programs.

Q133. Please provide a listing of the recipients of (i) the $8,940,000 in funding in FY 1995, (ii) the $14,500,000 in FY 1996 funding, and (iii) the requested level of $11,012,000 in FY 1997 for Hydrogen Research, including the funding for each recipient.

A133. The listing is provided as a table below in which the funding is in millions of dollars:

(In Millions of $)

Funding Recipients	FY 1995	FY 1996 (Est.)	FY 1997 (Est.)
NREL In-house	2.48	3.02	3.40
Sandia In-house	1.20	1.80	1.80
LLNL In-house	1.02	1.40	1.10
ORNL In-house	0.39	0.54	0.50
LANL In-house	0.46	0.65	0.5
SRTC In-house	0.0	0.85	0.5
Energy Conversion Devices	0.0	0.25	
A.D. Little	0.0	0.25	
University of Hawaii	0.69	0.75	
University of Miami	0.17	0.34	
Florida Solar Energy Center	0.18	0.32	
Solar Reactor Technologies	0.25	0.50	
Air Products and Chemicals	0.45	0.55	
Massachusetts Institute of Technology	0.2	0.2	
Directed Technologies	0.08	0.10	
Distributed Utility Associates	0.0	0.10	
Princeton University	0.15	0.20	
Jet Propulsion Laboratory	0.0	0.15	
Energetics	0.19	0.33	
R.K. Sen & Associates	0.85	0.35	
Hydrogen 2000	0.0	0.15	
City of Chula Vista	0.0	0.25	
Humboldt State	0.0	0.65	
International Fuel Cell	0.0	0.15	
National Hydrogen Association	0.15	0.35	
TBD	0.0	0.0	3.21
Total	**8.91**	**14.20**	**11.0**

Q134. For each recipient of Hydrogen Research funds identified in the response to question 133 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A134. The applied research conducted in the National Laboratories has little associated cost-sharing. Each university is providing 20 percent cost-sharing and the minimum cost-sharing by the industry participants is 35 percent.

Q135. For those Hydrogen Research funding recipients identified in the response to question 133 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A135. The Department's relationship with the National Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. However, the Hydrogen Program issued a competitive solicitation for the National Laboratories and peer reviewed all of the submitted proposals. All of the work funded at the National Laboratories has resulted from this process.

Non-competitive subcontract awards result from continuation of activities previously funded competitively, while others are awarded on the basis of unique expertise or exclusive capabilities. These non-competitive awards include: Princeton University, Florida Solar Energy Center, University of Miami, University of Hawaii, and Solar Reactor Technologies.

Electric Energy Systems and Storage

Q136. Please describe the "Superconductivity Partnership Initiative" (page 557 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), its progress and cost to date, expected date and cost of completion, and expected results at completion.

A136. SPI is an integral part of the DOE's Superconductivity Program is designed to meet the challenges of global competitiveness in a brand new technology. DOE has created this innovative vertically-integrated partnership structure to accelerate the typical technology development cycle. Industry cost-share is a minimum 50% of total cost for each project. Projects include the superconducting motor, generator, fault current limiter and transmission cable.

The objective of the motor project is to demonstrate a 5000-horsepower motor by 1998. A world record 200-horsepower motor was tested in March 1996 by the Reliance/DOE motor team to complete Phase I at a DOE cost to date of $3,500,000. Expected DOE cost at the end of Phase II is $12,450,000. Successful demonstration of the 5000 hp motor, which will have half the losses and 60% of the size of a conventional motor, will pave the way for industrial commercialization. Large motors use about 30% of the electricity generated in the US.

The objective of the generator coil project is to demonstrate a 100-MVA high-temperature superconducting coil by 1998. A coil is undergoing tests by the GE team to complete Phase I at a DOE cost to date of $ 2,525,000. Expected DOE cost at the end of Phase II is $3,500,000. Successful demonstration of the generator in 1998 will provide basic technologies needed for commercialization.

The objective of the fault current limiter project is to demonstrate a 15 kV limiter by 1997. A world record 2.4 kV limiter was tested in Sept. 1995 by the Lockheed-Martin/DOE team to complete Phase I at a DOE cost to date of $ 3,750,000. Fault current limiters protect utility grid equipment from abnormally large currents caused by lightning and shorts to ground. Expected DOE cost at the end of Phase II is $5,900,000. Successful demonstration of the 15-kV limiter will demonstrate their value for utility use in system protection, enhancing grid flexibility, and deferring upgrades.

The objective of the transmission cable project is to demonstrate a 30-meter, 115-kV prototype cable and a 3-phase, 100-meter design by 1998. A 50-meter cable that performed 50% over design specifications was tested in March 1996 by the Pirelli/DOE cable team at a DOE cost to date of $ 900,000. Expected DOE cost at the end of Phase II is $1,500,000. Successful demonstration of the cable will pave the way to meet the increasing power needs in crowded urban areas by retrofitting with superconducting cable, which will carry 3-5 times more current than conventional cable.

Supporting research was done at the National Laboratories, universities, and private companies in the areas of Wire Technology and Systems Technology. This is a continuing development of high temperature superconducting wire technology and its related systems technology which is an essential part of SPI integration. DOE cost to date is $20 million.

Q137. Page 558 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Superconductivity program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.00 Q**	**0.03 Q**	**0.15 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$0 M**	**$239 M**	**$1,025 M**
Carbon Equivalent Emissions Reductions	**0.00 MMT**	**0.62 MMT**	**2.82 MMT**

Q137a. Please provide detailed documentation of these claimed benefits.

A137a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies, industry estimates and other expert opinion. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from estimates of market penetration which, in turn, rely on projections of the cost of devices and equipment, such as motors and generators, using high temperature superconductor materials and estimates of the cost and efficiency savings from this technology. These cost and efficiency projections were reviewed by industry experts including the Electric Power Research Institute. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q137b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A137b. The benefits cited are based on the commercialization of high temperature superconductor device technologies being developed under the DOE program. The DOE Superconductivity program is in the forefront of U.S. research in this area. The benefits of this program are forecast to have a significant impact late in the forecast period. Without the DOE program it is likely that U.S. technology would not have the significant impact projected in the time frame of the benefits estimates given in the table. The Japanese and others are also developing this technology and any contribution to benefits would likely be from imported technology resulting from the R&D advances of these foreign programs.

Q138. Page 559 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Energy Storage program at the proposed funding levels:

	2000	2010	2020
Annual Primary Energy Displaced	**0.00 Q**	**0.02 Q**	**0.03 Q**
Annual Displaced Electricity Value ($0.07/kWh)	**$11 M**	**$112 M**	**$189 M**
Carbon Equivalent Emissions Reductions	**0.00 MMT**	**0.43 MMT**	**0.65 MMT**

Q138a. Please provide detailed documentation of these claimed benefits.

A138a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies, industry estimates and other expert opinion. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The estimates of projected benefits are derived from market penetration estimates for utility scale batteries from the Sandia National Laboratories report, *Battery Energy Storage: A Preliminary Assessment of National Benefits*, and for superconducting magnetic energy storage from an Electric Power Research Institute report, *SMES Benefits from a National Perspective.* The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q138b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A138b. The benefits cited are based on the commercialization of energy storage technologies being developed under the DOE program. Some research in this area would likely continue without the DOE program, but it is estimated that the progress of the technology will be delayed 5-10 years resulting in reductions of estimated benefits by as much as 70%.

Q139. Please provide a listing of the recipients of (i) the $17,748,000 in funding in FY 1995, (ii) the $22,585,000 in FY 1996 funding, and (iii) the requested level of $23,050,000 in FY 1997 for High Temperature Superconductivity R&D, including the funding for each recipient.

A139. This information is provided in the table below in which funding is in millions of dollars.

(In Millions of $)

Recipient	FY 1995	FY 1996	FY 1997
Argonne National Laboratory	4.050	2.495	3.600
Brookhaven National Laboratory	0.551	0.350	0.450
Los Alamos National Laboratory	3.900	3.435	4.500
National Renewable Energy Laboratory	0.855	0.645	0.750
Oak Ridge National Laboratory	5.028	4.875	6.000
Pacific Northwest National Laboratory	0.194	0.0	0.0
Sandia National Laboratories	0.970	0.665	0.665
CONTRACTS:			TBD
University of Tennessee	0.0	4.000	
University of Houston	0.370	0.0	
Lockheed-Martin	0.0	1.400	
Reliance Electric	0.0	1.550	
EPRI	0.300	0.300	
GE	0.875	0.150	
Total	**17.093**	**19.865**	**TBD**

Q140. For each recipient of High Temperature Superconductivity R&D funds identified in the response to question 139 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A140. This information is provided in the table below in which funding is in millions of dollars.

(In Millions of $)

Funding Recipient Cost-Sharing	FY 1995	FY 1996	FY 1997
Lockheed-Martin	1.100	1.400	TBD
Reliance Electric	1.000	1.400	TBD
GE	0.900	0.300	TBD
Total	**3.000**	**3.100**	**TBD**

Q141. For those High Temperature Superconductivity R&D funding recipients identified in the response to question 139 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A141. There are none.

Q142. Please provide a listing of the recipients of (i) the $4,792,000 in funding in FY 1995, (ii) the $2,000,000 in FY 1996 funding, and (iii) the requested level of $4,000,000 in FY 1997 for Energy Storage R&D, including the funding for each recipient.

A142. Funding by year with recipients. Funding is in millions of dollars.

(In Millions of $)

Recipient	FY 1995	FY 1996	FY 1997
Sandia National Laboratories	1.8	0.9	1.3
National Renewable Energy Laboratory	0.1		
Pacific Northwest National Laboratory	0.1		
CONTRACTS:			
Pacific Gas & Electric Corp.	0.2		
ZBB Technologies, Inc.	0.4	0.08	
AC Battery Corporation	0.2		
R.K. Sen & Associates	0.1		
Omnion Power Engineering Company	0.5		
Energetics, Inc.	0.3	0.1	
GNB Technologies, Inc.	0.15	0.05	
Johnson Controls, Inc.	0.2		
Contractors, TBD	0.8	0.4	2.7
Total	**4.85**	**1.53**	**4.0**

Q143. For each recipient of Energy Storage R&D funds identified in the response to question 142 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A143. The Energy Storage R&D program includes cost-sharing with a number of companies as listed below. Much of the work is performed in the National Laboratories and consequently there is limited cost-sharing.

(In Millions of $)

Funding Recipient Cost-Sharing	FY 1995	FY 1996	FY 1997
Pacific Gas & Electric Corp.	0.10		
Omnion Power Engineering Company	0.85		
Contractors, TBD (Competitive)	0.0	0.85	TBD
GNB Technologies, Inc.	0.10	0.05	TBD
Total	**1.05**	**0.90**	**TBD**

Q144. For those Energy Storage R&D funding recipients identified in the response to question 142 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A144. Non-competitive awards result from continuation of activities previously funded competitively, or are awarded on the basis of unique or exclusive capabilities. Non-competitive awards include: Pacific Gas & Electric Corp.; R.K. Sen & Associates; Energetics, Inc.; Omnion Power Engineering Co.; and AC Battery Corporation.

Q145. Please provide a listing of the recipients of the $5,784,000 in funding in FY 1995 for Transmission and Distribution R&D, including the funding for each recipient.

A145. The recipients of funding in FY 1995 for Transmission and Distribution R&D, and the funding for each recipient are:

Oak Ridge National Laboratory	$3,489,027
Bonneville Power Administration	$750,000
Jet Propulsion Laboratory	$609,000
Energetics, Inc	$158,000
Pacific Northwest National Laboratories	$147,000
Universities, consultants, and others	$630,521
Total	$5,783,548

Q146. For each recipient of Transmission and Distribution R&D funds identified in the response to question 145 above, please provide the level of funding provided by that recipient as cost-sharing for FY 1995.

A146. The Bonneville Power Administration provided $1,470,000 in cost-sharing in FY 1995.

Q147. For those Transmission and Distribution R&D funding recipients identified in the response to question 145 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A147. National Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplishment work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Bonneville Power Administration and the Jet Propulsion Laboratory were provided non-competitive funding on the basis of unique expertise and exclusive capabilities.

Q148. On page 568 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that Transmission and Distribution R&D will be "closed out with prior year funds." Please identify the amount prior year funds that will be used.

A148. Prior year Transmission and Distribution R&D funds to be used to close the program are $2,716,620.

Q149. Please provide a listing of the recipients of (i) the $13,064,000 in funding in FY 1995, (ii) the $9,699,000 in FY 1996 funding, and (iii) the requested level of $8,000,000 in FY 1997 for Electric and Magnetic Fields R&D, including the funding for each recipient.

A149. A listing of EMF program funds recipients follows:

(In Thousands of $)

Recipient	FY 1995	FY 1996	FY 1997
Oak Ridge National Laboratory	3,318	3,014	2,425
Pacific Northwest National Laboratory	1,215	1,100	800
Lawrence Berkeley National Laboratory	300	300	200
Argonne National Laboratory	175	150	100
National Institute of Standards and Technology	220	140	

Recipient	FY 1995	FY 1996	FY 1997
Veterans Administration	750	750	
Environmental Protection Agency	265	200	
National Academy of Sciences	153	25	0
National Institute of Environmental Health Science	5,750	2,605	
National Institute of Occupational Health & Safety	95	60	60
National Institute of Standards and Technology	40	40	
Department of Transportation	50	50	
TBD	0	0	4,475
Total	12,331	8,434	8,060

Q150. For each recipient of Electric and Magnetic Fields R&D funds identified in the response to question 149 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A150. The recipients identified above do not provide matching funds.

Q151. For those Electric and Magnetic Fields R&D funding recipients identified in the response to question 149 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A151. Funding is provided to both NIEHS and NAS in accordance with the provisions of the Energy Policy Act of 1992. Funding at National Laboratories and through Interagency Agreements is based on determinations by DOE program managers that staff and facilities at these institutions are uniquely qualified to accomplish the required work. The Department's relationship with the National Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

National Renewable Energy Laboratory

Q152. On page 572 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that the Field Test Laboratory Building (FTLB) Expansion, Phase II, "is the continuation of the previously approved Line Item Construction Project No, 96-E-100, funded in FY 1996 for $1.5M and is Phase II of a three phase project."

Please describe Phase III, including its scope, schedule, cost, and out-year funding requirements.

A152. FTLB Expansion - Phase III completes the project and consists of the design and construction of a high bay building addition to house Process Development Unit (PDU) sized projects in support of the funded research in thermal conversion technologies and the renovation of existing laboratory research areas. PDU research and development activities are currently housed in expensive leased space or subcontracted to third party company sites (which hinders the Laboratory's ability to enter into additional Cooperative Research and Development Agreements (CRADAs) with industrial partners). Phase III will also complete the realignment of laboratory/space areas within the FTLB to provide for optimal operational efficiencies. This work will start in FY98 and be completed in FY99. The cost for Phase III will be $2,200,000. No additional outyear construction funding is anticipated.

Program Direction - EE

Q153. On page 589 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that one of the 1995 accomplishments was to participate "as one of the Government Performance and Results Act-National Performance Review Reinvention Lab pilots."

Please describe the results to date.

A153. The Office of Energy Efficiency and Renewable Energy (EE) pilot under the Government Performance and Results Act (GPRA) met the goals set out for FY 1995. FY 1995 was the first year for most of the programs in this GPRA pilot, comprised of eight of the more than twenty programs that are part of the EE Energy Partnerships for a Strong Economy initiative: Rebuild America, Climate Wise, NICE-3, and five Renewable Energy Commercialization programs: Wind, Photovoltaic, Geothermal Power, Geothermal Heat Pumps, and Biomass. The programs have an approach to planning, performance measurement, and implementation that relies on stakeholder involvement and evaluation.

FY 1995 was an important year for laying the foundation for future Energy Partnership program success. The programs in the pilot were remarkably successful in the key part of laying this foundation–establishing partnerships. Partner recruitment exceeded targets across the board. Overall, programs made good progress as measured by program-specific short-term outcomes, although budget reductions from initial targets impacted program progress. Methods for estimating program outcomes for the year 2000 and beyond have been refined and reviewed by external experts. The EE GPRA pilot has been used as a model, with some improvements, for EE-wide performance measurement activities.

154. On page 589 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that one of 1996 accomplishments is "De-layer Project Management." Which specific projects have been or will be transferred from Headquarters to the field offices?

154. Transferring certain Project Management responsibilities from Headquarters to the Field/Support Offices reduces duplication of effort. Redundancy occurs when Project Management is conducted at both the Headquarters and the Field. Additionally, Project Management is more effective when this function is closer to the customer. Thus, de-layering project management involves transferring certain project management responsibilities from Headquarters to the Field/Support Offices.

155. On page 591 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that one of 1997 planned accomplishments is to "[d]evelop a comprehensive, integrated, peer reviewed, state-of-the-art system of estimates and performance measures across all solar and renewable energy programs.

Q155a. Please describe the current system and why changes are needed.

A155a. In 1994 EE initiated a process to improve its ability to estimate benefits of its programs–Quality Metrics. Quality Metrics is a process that estimates the outyear marketplace impacts due to EE's programs on energy, economy, employment, and environment. The goal was to develop credible estimates of program benefits in terms of impacts on energy use, economic growth, employment and environmental emissions. This process made use of expert analysts from within EE, national labs and outside organizations. State of the art analytical techniques are used to develop the estimates and extensive outside reviews of results are conducted. These reviews have included: process review of estimation methodologies involving many external groups, review of specific technologies or groups of technologies–over 80 experts in specific technical fields in the first year alone; a cross-sectoral review conducted by Arthur D. Little, Inc.; collaboration with the Energy Information Agency to use the National Energy Modeling System to run the analysis as well as consulting with the analysts within EIA to further improve the methodology. According to A. D. Little, "The overall QM process has been well executed and provided results which are, in general, reasonable relative to energy use issues. Equally important, the process has helped identify programmatic areas requiring additional assessment and laid the groundwork for a refined and ongoing QM activity which incorporates the lessons learned from the first iteration."

As with any analytical system, improvements can be made to increase the accuracy and credibility of the estimates. Three improvements needed for FY 1997 are better documentation of assumptions; improved internal consistency between program performance measures (as required by the Government Performance and Results Act) and estimates of future benefits; and a more diversified peer review.

Q155b. Please describe the planned "peer review" process. Who will conduct the peer review?

A155b. In order to develop the best possible estimates of program benefits, the peer review process in FY 1997 will include representation by a wide variety of groups including manufacturers, academics, consumer groups, think tanks, State governments and others. The peer review will be coordinated by a third party group–Arthur D. Little, Inc. to ensure impartiality.

In-House Energy Management

Q156. Please provide a listing of the recipients of (i) the $30,049,000 in funding in FY 1995, (ii) the $342,000 in funding in FY 1995, and (iii) the requested level of $5,259,000 in FY 1997 for In-House Energy Management Facilities Operations, including the funding for each recipient.

A156. The following chart lists projects and surveys funded by the In-House Energy Management Program (IHEM) in FY 1995. This list includes some projects and studies that were funded with FY 1994 carryover funds.

In 1996, $342,000 supports the salary, benefits, and travel for a staff of four In-House Energy Management Program employees.

The requested level of $5,259,000 for FY 1997, will be distributed to many of the same sites that are listed in our attachment. The IHEM Program is in the process of receiving requests for these funds currently, and has not made any funding decisions at this time.

In-House Energy Management Funded Projects

Non Cost-Share (in Thousands of $)				
No.	**Recipient**	**FY 1995**	**FY 1996**	**FY 1997**
1	DOE-Albuquerque	68		
2	Grand Junction Project Office	50		
3	Inhalation Toxicology Research Institute	1,270		
4	Kansas City Plant	285		
5	Los Alamos National Laboratory	555		
6	Sandia National Laboratories, California	1,450		
7	Sandia National Laboratories, New Mexico	132		
8	Argonne National Laboratory, East	2,295		
9	Brookhaven National Laboratory	3,556		
10	Fermi National Accelerator Laboratory	2,521		
11	Princeton Plasma Physics Laboratory	383		
12	Nevada Test Site	1,247		
13	Energy Technology Engineering Center	80		
14	Lawrence Berkeley National Laboratory	1,964		
15	Lawrence Livermore National Laboratory	2,670		
16	Continuous Electron Beam Accelerator Fac.	990		
17	JCTLS-Oak Ridge, TN	37		
18	K-25 Plant - Oak Ridge, TN	3,631		
19	Oak Ridge Institute for Science & Education	14		
20	Oak Ridge National Laboratory	1,677		
21	Y-12 Plant - Oak Ridge, TN	950		
22	Oak Ridge, Office of Science & Tech. Info.	325		
	Total	**26,150**		

In-House Energy Management Funded Surveys

Non Cost-Share (in Thousands of $)				
No.	**Recipient**	**FY 1995**	**FY 1996**	**FY 1997**
1	Kansas City Plant	39		
2	PANTEX Plant	100		
3	Sandia National Laboratories, California	128		
4	DOE-Chicago	200		
5	Ames Laboratory	9		
6	Argonne National Laboratory, East	100		
7	Brookhaven National Laboratory	258		
8	Fermi National Accelerator Laboratory	85		
9	Princeton Plasma Physics Laboratory	170		
10	National Renewable Energy Laboratory	95		
11	DOE-HQ, Forrestal	30		
12	Idaho National Engineering Laboratory	266		
13	Naval Petroleum Reserve 3	26		
14	Nevada Test Site	49		
15	Energy Technology Engineering Center	27		
16	Lawrence Berkeley National Laboratory	550		
17	Lawrence Livermore National Laboratory	1,091		
18	Oak Ridge	200		
19	Continuous Electron Beam Accelerator Fac.	31		
20	K-25 Plant - Oak Ridge, TN	478		
21	Oak Ridge Institute for Science & Education	29		

Non Cost-Share (in Thousands of $)				
No.	Recipient	FY 1995	FY 1996	FY 1997
22	Oak Ridge National Laboratory	317		
23	Y-12 Plant - Oak Ridge, TN	429		
24	Oak Ridge, Office of Science & Tech. Info.	13		
25	Pittsburgh Energy Technology Center	50		
26	Pacific Northwest National Laboratory	332		
27	Westinghouse-Hanford Co.	475		
28	Savannah River Site	143		
	Total	5,720		

Q157. Please describe the Energy Savings Performance Contract to be completed in FY 1996 (page 600 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*).

A157. The Department of Energy is preparing to enter into a 25-year energy savings performance contract for heating system energy efficiency improvements at its Hanford, Washington site. The contract requires the energy services contractor to finance, design, install, operate and maintain the heating systems and implement energy efficiency improvements in return for a share of the cost savings. The Department's share of the cost savings over the life of the project is projected to be over $100 million. To achieve the cost savings, the contractor will install heating system and energy efficiency improvements. The contractor will also operate and maintain the installed systems for the term of the contract.

Q158. Please describe the planned initiation of two Energy Savings Performance Contracts to be completed in FY 1997 (page 600 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*), including date of completion.

A158. The Department of Energy through its In-House Energy Management Program (IHEM), currently has energy savings performance contracts under development at its sites, at headquarters for all sites, or awaiting funding to be initiated at a number of sites. A brief description of these energy savings performance contract (ESPC) efforts and their expected completion dates follows:

a. Headquarters Indefinite Delivery/Indefinite Quantity ESPC for Integrated Chiller and Energy Conservation Retrofits. This contract, which is being developed by the IHEM Program, will be for the replacement of inefficient chillers, integrated with a comprehensive selection of energy conservation measures that improve the energy conservation savings of the project while reducing the cooling load. This contract will also support the regulatory phase-out of chlorofluorocarbons that are used in the Department's current chillers. It is expected that this contract will be awarded in FY 1997.

b. Lawrence Livermore National Laboratory ESPC. This will be a site-wide contract for ESPC services. The IHEM Program provided FY 1995 funding for this effort. The site has already issued a Notice requesting Expressions of Interest, and has received over 20 responses. It is expected that the solicitation will be issued in FY 1996, with award by early FY 1997.

c. Argonne National Laboratory ESPC. The laboratory is currently investigating-use of ESPC for a 25-megawatt cogeneration plant and lighting retrofits. The lab has requested funding from the IHEM Program to support this effort, and is waiting for FY 1997 funding. It is expected that this effort will be initiated in FY 1997, with contract award in FY 1998.

d. Pantex Plant ESPC. The plant is evaluating use of ESPC for site-wide energy conservation services. The plant has requested funding support form the IHEM Program, and is waiting for FY 1997 funding. It is expected that this effort will be initiated in FY 1997, with contract award in FY 1998.

e. Fermi National Accelerator Laboratory ESPC. The laboratory is investigating use of ESPC for central cooling system retrofits. The laboratory has requested funding from the IHEM Program, and is waiting for FY 1997 funding. It is expected that this effort will be initiated in FY 1997, with contract award in FY 1998.

Energy Conservation R&D

Transportation Sector

Q159. Page 267 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains a table with various transportation consumption, U.S. oil import and production figures, etc., for the years 1973, 1993, 2000, 2010, and 2020. Figures for the years 2000, 2010 and 2020 are as follows:

	2000	2010	2020
Share of U.S. Oil Imported	60.6	63.7	67.0
Transportation Oil Use/Domestic Oil Production	2.23	2.56	2.8
Number of U.S. Light Duty Vehicles (millions)	224	259	289
Transportation Oil Use (million barrels per day)	12.59	13.93	15.41
Net Oil Imports (mbpd)	10.08	11.84	13.86
Direct Cost of Imported Oil (billions of 1994 $)	$79	$122	$180
Transportation Carbon Emissions (million metric tons per year)	492	552	613
New Car Fuel Economy (mpg)	28.1	31.5	32.8
New Light Truck FE (mpg)	20.7	23.5	25.1

Q159a. Please provide documentation supporting these estimates.

Q159b. Please compare these estimates with those of the Energy Information Administration (EIA) contained in the EIA's *Annual Energy Outlook 1996*, and explain any differences.

A159. All estimates, with the exception of Share of U.S. Oil Imported, on page 267 of Volume 4 (of 5) of the FY 1997 Congressional Budget Request are taken directly from the "Annual Energy Outlook 1996" (DOE/EIA-0383(96)). Estimates shown for Share of U.S. Oil Imported were taken from the "Annual Energy Outlook 1995" (DOE/EIA-0383(95)).

Q160. Page 268 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains a table with claims of improvements to new car and new light truck MPG, carbon emission reductions, direct oil savings, and increased use of renewables for the years 2000, 2010 and 2020 as follows:

Improvements Due to OTT Programs:	**2000**	**2010**	**2020**
New Car MPG	**29.5**	**42.1**	**47.5**
New Light Truck MPG	**21.7**	**31.4**	**36.3**
Carbon Emission Reductions			
Million Metric Tons	**0.8**	**55.5**	**110.0**
% Carbon Reduced	**0.2%**	**10.0%**	**17.9%**
Direct Oil Savings			
Million Barrels per Day (MBPD)	**0.06**	**1.57**	**2.84**
% Oil Imports Reduced	**0.5%**	**11.3%**	**18.4%**
Increased Use of Renewables (MBPD Oil Equivalents)	**0.01**	**0.41**	**0.60**

Q160a. Please provide detailed documentation, including assumptions, that supports these claims.

A160a. Estimates of new car and new light truck fuel economy reflect the sales weighted averages of those vehicles estimated to be sold in those years. It is assumed that advanced diesel, aluminum intensive, dedicated alcohol, hybrid, electric and fuel cell technologies penetrate both the car and light truck markets. It is also assumed that those technologies are the only ones having a marketable increase in fuel economy. The table below illustrates the expected light duty vehicle average new car fuel economy given the estimated market penetrations of advanced technologies.

New Light Duty Vehicle Fuel Economy	2000	2010	2020
Conventional Vehicle	24.5	27.3	28.7
Advanced Diesel Vehicle	N/A	36.9	38.7
Aluminum Intensive Vehicle	N/A	33.0	34.7
Dedicated Alcohol Vehicle	28.2	31.4	33.0
Alcohol Flex-Fuel Vehicle	24.5	27.3	28.7
LPG Vehicle	24.5	27.3	28.7
CNG Vehicle	24.5	27.3	28.7
Hybrid I Vehicle	N/A	57.3	60.2
Hybrid II Vehicle	N/A	74.3	86.0
Electric Vehicle	99.5	142.0	149.1
Fuel Cell Vehicle	N/A	72.1	86.0
LDV Sales Weighted CAFE	**25.4**	**36.5**	**41.5**

Carbon emission reductions reflect the total carbon equivalent emission reductions realized through the program success of advanced technologies and alternative fuels being developed by the Office of Transportation Technologies. The table below illustrates the impact each program has on total carbon emission reductions.

Carbon Emission Reductions (MMTons)	2000	2010	2020
Alternative Fuel Vehicle R&D	0.23	0.81	0.49
Biofuels	0.57	15.75	18.88
Electric Vehicle R&D	-0.06	0.44	0.45
Fuel Cell R&D	0.0	2.11	20.90
Heavy Duty R&D	0.097	8.50	27.45
Hybrid Vehicle R&D	0.0	20.27	33.80

Carbon Emission Reductions (MMTons)	2000	2010	2020
Light Duty Engine R&D	0.0	4.05	4.43
Light Weight Materials R&D	0.0	3.59	4.01
Total Carbon Emission Reduction	**0.83**	**55.51**	**100.42**
Total Carbon Emissions (AEO'96, p. 118)	491.8	552.4	591.0
Reductions as a % of Total Carbon Emissions	**0.0%**	**0.2%**	**18.4%**

Direct oil savings reflect the cumulation of oil savings by each of the programs conducted by the Office of Transportation Technologies. Sensitivity runs of the Alternative Fuels Trade Model (AFFM) conducted by the DOE Policy Office indicate the every barrel of oil saved by conservation or fuels switching is a direct reduction in oil imports.

Direct Oil Savings (MBPD)	2000	2010	2020
Alternative Fuel Vehicle R&D	0.04	0.11	0.06
Biofuels	0.01	0.41	0.60
Electric Vehicle R&D	0.01	0.13	0.10
Fuel Cell R&D	0.0	0.04	0.39
Heavy Duty R&D	0.0	0.20	0.65
Hybrid Vehicle R&D	0.0	0.49	0.82
Light Duty Engine R&D	0.0	0.11	0.12
Light Weight Materials R&D	0.0	0.09	0.10
Total Oil Savings	**0.06**	**1.57**	**2.84**
Oil Imports (AEO'96, p. 102)	10.08	11.84	11.74
Savings as a % of Imports	**0.5%**	**11.3%**	**18.4%**

Increased use of renewables reflects the production and use of biomass-based ethanol for the transportation sector. The vehicles utilizing this fuel include: flex-fuel vehicles, dedicated alcohol vehicles, and fuel cell vehicles.

Increased Use of Renewables (MBPD equivalent)	2000	2010	2020
Flex-fuel Vehicles	0.01	0.32	0.32
Dedicated Alcohol Vehicles	0.00	0.07	0.15
Fuel Cell Vehicles	0.00	0.02	0.13
Total	**0.01**	**0.41**	**0.60**

Q160b. Please provide specific evidence that these improvements would not occur without the DOE funding.

A160b. These aggregate estimated Office of Transportation Technologies (OTT) benefits would probably not occur without DOE funding. The program-by-program rationales for this statement are presented in answers 62b, 163b, 184b, 185b, 186b, 198b, 206b, and 207b.

Q161. On page 270 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Technologies under development in OTT are estimated to reduce transportation oil demand by 1.6 million barrels per day in 2010 if program goals are met. . . The energy cost savings resulting from OTT programs, estimated to be $23 billion in 2010, will help create U.S. jobs as consumer spending is directed toward labor-intensive service industries. . . OTT programs will help to reduce oil imports (estimated at 65 percent of U.S. consumption in 2010 by EIA). . OTT technologies are expected to reduce carbon equivalent emissions by 56 million metric tons in 2010. . ."

Q161a. Please provide detailed documentation, including assumptions, that supports these claims.

A161a. The estimates reflect the cumulated benefits realized through the success of all OTT programs. The following table illustrates the benefits accomplished by the programs in 2010.

Program	Oil Reduction (MBPD)	Energy Cost Savings (Billions of $)	Carbon Reduction (MMTons)
Alternative Fuel Vehicle R&D	0.11	0.71	0.81
Biofuels	0.41	0.08	15.75
Electric Vehicle R&D	0.13	2.00	0.43
Fuel Cell R&D	0.04	0.84	2.11
Heavy Duty R&D	0.20	4.19	8.50
Hybrid Vehicle R&D	0.49	11.53	20.27
Light Duty Engine R&D	0.11	2.51	4.05
Light Weight Materials R&D	0.09	2.04	3.59
Total	**1.58**	**22.97**	**55.51**

Q161b. Please provide specific evidence that these improvements would not occur without the DOE funding.

A161b. The estimated 1.6 million barrels per day (mbpd) saving in 2010 is rounded off from the 1.57 mbpd estimate provided in question 160. Likewise, the 56 million metric tons of carbon (MMTons) reduced is rounded off from the 55.5 MMTons in question 160. The estimated $23 billion in energy cost savings is the result of adding the energy cost savings of each of the program technologies. These energy cost savings are obtained by multiplying the amount of reduced oil use by the price of the oil.

Q162. Please describe the U.S. Advanced Battery Consortium (USABC), provide a list of USABC projects and costs to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A162. The United States Advanced Battery Consortium (USABC) is a partnership of Chrysler, Ford, and General Motors which sponsors pre-competitive research in advanced batteries for electric vehicles. It also conducts research in high power energy storage in support of the Partnership for a new Generation of Vehicles. Current projects are listed as follows:

USABC Phase I:

Total Cost to Date (based on December 1995): $171 million (50% government)
Expected Date of Completion: July 1997
Total (Estimated) Cost to Completion: $192 million (50% government)
Results at Completion: (1) Prototype mid-term batteries approaching the Consortium's mid-term goals in pilot production and proceeding to be validated in manufacturers electric vehicles; (2) Technical feasibility of battery technology meeting long-term goals demonstrated.

USABC Phase II–In negotiation with USABC:
Total Cost to Date: None
Expected Date of Completion: December 1999
Total (Proposed) Cost of Completion: $106 million (45% government)
Results at Completion: Prototype long-term batteries approaching the Consortium's long-term goals in pilot production, proceeding towards validation testing in manufacturers vehicles.

USABC High Power Energy Storage–Phases I and II:
Total Cost to Date: None
Expected Date of Completion: September 1997
Expected Cost at Completion: $35 million (50% government)
Results at Completion: At the completion of Phase II, one or more high power energy storage technologies would be-demonstrated in prototype 50-volt, full-current modules. One technology would be selected for full vehicle prototype development.

Alternative Fueled Vehicles

Q163. On page 277 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "In concert with regional and local authorities, partnerships will be created among fuel suppliers, vehicle manufacturers, and fleet operators to increase the number of alternative fuel vehicles and the number of refueling facilities so that 300,000 alternative fuel vehicles will be added nationally by the year 2000, thereby displacing 0.04 mbpd of petroleum, reducing carbon emissions by 0.23 million metric tons per year, and reducing annual energy costs by $170 million by the year 2000.

Q163a. Please provide detailed documentation, including assumptions, that supports these claims.

A163a. Although alternative fuel vehicle sales will be over 300,000 annually by year 2000, the benefits are realized through 795,000 liquefied petroleum gas (LPG) and 235,000 compressed natural gas (CNG)-vehicles in use. LPG vehicles begin significant market penetration in year 1998 while CNG vehicles significantly penetrate the light duty vehicle market in 2000. The cumulation of these vehicles result in the benefits stated above. The table below illustrates the benefit contribution by fuel type.

Technology	Oil Reduction (MBPD)	Energy Cost Savings (Millions of $)	Carbon Reduction (MMTons)
LPG	0.03	93	0.14
GNG	0.01	75	0.09
Total	0.04	168	0.23

Q163b. Please provide specific evidence that these improvements would not occur without the DOE funding.

A163b. Some of the future estimated benefits of the Alternative Fueled Vehicles program would probably be realized even if DOE funding were stopped. The Clean Cities momentum would probably continue to some extent without DOE funding. Likewise, some fuel providers would acquire some alternative fuel vehicles even if DOE did not provide the regulatory force that targets specific levels of alternative fuel vehicle purchases.

Q164. Page 277 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Alternative Fueled Vehicles program:

	2000	2010	2020
Primary Energy Displaced (Quads)	**0.00**	**0.00**	**0.00**
Primary Oil Displaced (MBPD)	**0.04**	**0.11**	**0.06**
Energy Cost Savings ($B)	**0.17**	**0.71**	**0.36**
Carbon Reductions (MMTons)	**0.23**	**0.81**	**0.49**

Q164a. Please provide detailed documentation of these claimed benefits.

A164a. To estimate the market impact of alternative fuel vehicle research and development, estimations of fuel and vehicle attributes were made for conventional and advanced technologies (including CNG- and LPG-fueled light duty vehicles)[1]. These estimations were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations[2]. Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model[3]. The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Fulton, Lewis M. "Alternative-Fuel Vehicles and The Energy Policy Act: A Case Study in Technology Policy." Diss. U. of Pennsylvania, 1994.

[3] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ESD/TM-93), Argonne National Laboratory, Argonne, IL. December 1994.

(miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using AVS 8.1, it was estimated that LPG fueled light duty vehicles would enter the market in 1998, and CNG fueled vehicles in 2000. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings and carbon reductions of these technologies.

	2000	2010	2020
Market Penetration			
LPG	1.9%	0.6%	0.5%
CNG	1.5%	0.6%	0.5%
Percent of Total Light Duty Vehicles			
LPG	0.4%	0.9%	0.5%
CNG	0.1%	0.9%	0.6%
Alternative Fuel Used(MBPD)*			
LPG	0.03	0.06	0.03
CNG	0.01	0.05	0.03
Total	0.04	0.11	0.06
Gasoline Displaced(MBPD)			
LPG	0.03	0.06	0.03
CNG	0.01	0.05	0.03
Total	0.04	0.11	0.06
Energy Cost Savings(Billions of $)			
LPG	0.09	0.20	0.10
CNG	0.08	0.51	0.26
Total	0.17	0.71	0.36
Carbon Reductions (MMTons)			
LPG	0.14	0.27	0.15
CNG	0.09	0.55	0.34
Total	0.23	0.82	0.49

*Million Barrels per Day, equivalent to oil on a Btu basis.

Q164b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A164b. Please refer to the answer to question 163b. [Reproduced here.]

Some of the future estimated benefits of the Alternative Fueled Vehicles program would probably be realized even if DOE funding were stopped. The Clean Cities momentum would probably continue to some extent without DOE funding. Likewise, some fuel providers would acquire some alternative fuel vehicles even if DOE did not provide the regulatory force that targets specific levels of alternative fuel vehicle purchases.

Q165. Please describe the Clean Cities program, including program participants, and DOE funding for FY 1994 - FY 1997, by participant.

A165. Clean Cities is a *locally-based* government/industry partnership, coordinated by DOE to expand the use of alternatives to gasoline and diesel fuel. The program has created partnerships in 46 communities and is comprised of 1,900+ stakeholder organizations, including local and State governments, fuel suppliers, fleet operators, vehicle manufacturers, environmental groups, and business and community leaders.

Funds are primarily allocated among DOE program offices and select contractors to provide technical assistance for planning and coalition building; encourage capital investments; provide program guidance; and facilitate trouble-shooting and communications.

Because the DOE Clean Cities program is based on providing technical assistance to encourage voluntary action and local initiative, the overwhelming majority of funds are not allocated directly to participating cities. The program, however, has been successful in helping cities attract funding of other types. For instance, the Gas Research Institute offered its $500,000 technology deployment budget to the local Clean Cities participants because they believe that Clean Cities locations are "ahead of the curve," and represent the most fertile locations to invest their resources and to stimulate further market development. The following participants are among the limited exceptions for direct funding to support specific projects or technology demonstration:

	FY 1996
Clean Air Group of Atlanta	$80,000
West Virginia Natural Gas Vehicle Coalition	$15,000
City and County of Denver	$50,000
Governors Ethanol Coalition	$20,000
California Natural Gas Vehicle Coalition	$15,000
Total	$180,000

Results from these projects will be generalized and shared with all participating communities. A list of participating Clean Cities follows:

LIST OF PARTICIPATING CLEAN CITIES

1.	Atlanta	September 8, 1993
2.	Denver	September 13, 1993
3.	Philadelphia	September 22, 1993
4.	Wilmington	October 12, 1993
5.	Las Vegas	October 18, 1993
6.	Washington D.C.	October 21, 1993
7.	Boston	March 18, 1994
8.	Austin	April 18, 1994
9.	Florida Gold Coast	May 5, 1994
10.	Chicago	May 13, 1994
11.	Albuquerque	June 1, 1994
12.	Wisconsin SE Area	June 29, 1994
13.	Colorado Springs	July 13, 1994
14.	Long Beach	August 31, 1994
15.	Lancaster	September 22, 1994
16.	Salt Lake City	October 3, 1994
17.	White Plains	October 4, 1994
18.	Baltimore	October 7, 1994

19.	Louisville	October 18, 1994
20.	Rogue Valley	October 18, 1994
21.	West Virginia	October 18, 1994
22.	Oakland	October 21, 1994
23.	San Francisco	October 21, 1994
24.	San Joaquin Valley	October 21, 1994
25.	Sacramento	October 21, 1994
26.	South Bay (San Jose)	October 21, 1994
27.	Western New York	November 4, 1994
28.	Portland	November 10, 1994
29.	St. Louis	November 18, 1994
30.	Norwalk	November 21, 1994
31.	Waterbury	November 21, 1994
32.	Norwich	November 22, 1994
33.	New London	November 22, 1994
34.	Peoria	November 22, 1994
35.	SW Kansas	March 30, 1995
36.	Central New York	June 15, 1995
37.	Dallas-Fort Worth	July 25, 1995
38.	Honolulu	August 29, 1995
39.	Missoula	September 21, 1995
40.	New Haven	October 5, 1995
41.	Central Arkansas	October 25, 1995
42.	Paso del Norte	November 17, 1995
43.	Pittsburgh	December 5, 1995
44.	Southern California Association of Governments	March 1, 1996
45.	Los Angeles	March 22, 1996
46.	Coachella Valley	April 22, 1996
Planned		
47.	Rocky Mountain National Park	May 22, 1996
48.	Oklahoma City	May 29, 1996

Q166. On page 278 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* it is stated that 1995 DOE accomplishments included development of "a variety of alternative fuel engines with heavy duty engine manufacturers, including the John Deer 8.1 Powerteck compressed natural gas (CNG), the Navistar DTA 466 CNG, the Detroit Diesel DDC 6V92M95-E-95 (ethanol), the Caterpillar 3306 E-95-M-95 (ethanol and methanol), and the Hercules GTA 3.7L CNG engines."

Q166a. Please describe each of these developments and provide both DOE and private sector funding for each during the period of development.

A166a. The following table provides a listing of the engines, manufacturers, and funding levels.

Engine	DOE Total Project Funding	Industry Cost-Share	Prime Contractor
(1) John Deere 8.1-L Powertech	$840,000	$1,000,000	SWRI John Deere Blue Bird Bus
(2) Navistar DTA-466	$200,000	$750,000	Tecogen
(3) DDC 6V92 M95/E95	$650,000	$650,000	Detroit Diesel
(4) Caterpillar 3306 Flex Fuel	$1,365,000	$341,000	Caterpillar
(5) Hercules GTA3.7L	$875,000	$200,000	West Virginia University
Total	$3,930,000	$2,941,000	

(1) The development of this engine was done at Southwest Research Institute in a joint effort with John Deere (to develop a natural gas powered school bus engine). This engine was Deere's first entry into the over-the-road engine market.

(2) This engine is the mainstay engine in the school bus market and has a large population in the heavy duty vehicle class. This development builds in the capability for this engine to be produced or converted to operate on natural gas and meet EPA/California emissions standards.

(3) This engine is the predominant engine in municipal transit bus applications. Detroit Diesel modified it to operate on methanol and ethanol under this program. This engine meets all EPA/California emissions standards.

(4) This engine is being developed by Caterpillar in an attempt to introduce flexible-fuel capability into heavy duty class vehicles. This will allow heavy duty, over-the-road vehicles to operate on alcohol fuels in non-attainment areas and meet emissions regulations associated with these areas. These areas have alternative fuels available. In areas where emissions regulations are less stringent (generally rural areas), the vehicles will operate on petroleum-based diesel fuel.

(5) This engine was first developed by Hercules to operate on natural gas. The first attempt at commercialization met with failure. Hercules turned to the Federal government to assist it in developing a solution to the engine's problems. West Virginia University, with Federal funds and the cooperation of Hercules, developed a feedback control system for the engine which solved the problem, providing Hercules with a commercially viable product, and increasing the availability of alternative fuel engines in the market.

Q166b. Please provide evidence that these engines would not have been developed in the absence of DOE funding.

A166b. None of these engines would have been developed in the absence of Federal funding because, at the present time, alternative fuel costs are higher than petroleum-based fuels. Engine manufacturers cannot show an adequate return on investment for developing alternative fuel technology.

Q167. Please describe the Johns Hopkins Advanced Natural Gas Vehicle, and provide both DOE and private sector funding during its development.

A167. The Advanced Natural Gas Vehicle is a GEO Prism that operates with a replacement engine tailored to natural gas, incorporates chassis and rear-suspension modifications to

Engine	DOE Total Project Funding	Industry Cost-Share	Prime Contractor
(1) John Deere 8.1-L Powertech	$840,000	$1,000,000	SWRI John Deere Blue Bird Bus
(2) Navistar DTA-466	$200,000	$750,000	Tecogen
(3) DDC 6V92 M95/E95	$650,000	$650,000	Detroit Diesel
(4) Caterpillar 3306 Flex Fuel	$1,365,000	$341,000	Caterpillar
(5) Hercules GTA3.7L	$875,000	$200,000	West Virginia University
Total	$3,930,000	$2,941,000	

(1) The development of this engine was done at Southwest Research Institute in a joint effort with John Deere (to develop a natural gas powered school bus engine). This engine was Deere's first entry into the over-the-road engine market.

(2) This engine is the mainstay engine in the school bus market and has a large population in the heavy duty vehicle class. This development builds in the capability for this engine to be produced or converted to operate on natural gas and meet EPA/California emissions standards.

(3) This engine is the predominant engine in municipal transit bus applications. Detroit Diesel modified it to operate on methanol and ethanol under this program. This engine meets all EPA/California emissions standards.

(4) This engine is being developed by Caterpillar in an attempt to introduce flexible-fuel capability into heavy duty class vehicles. This will allow heavy duty, over-the-road vehicles to operate on alcohol fuels in non-attainment areas and meet emissions regulations associated with these areas. These areas have alternative fuels available. In areas where emissions regulations are less stringent (generally rural areas), the vehicles will operate on petroleum-based diesel fuel.

(5) This engine was first developed by Hercules to operate on natural gas. The first attempt at commercialization met with failure. Hercules turned to the Federal government to assist it in developing a solution to the engine's problems. West Virginia University, with Federal funds and the cooperation of Hercules, developed a feedback control system for the engine which solved the problem, providing Hercules with a commercially viable product, and increasing the availability of alternative fuel engines in the market.

Q166b. Please provide evidence that these engines would not have been developed in the absence of DOE funding.

A166b. None of these engines would have been developed in the absence of Federal funding because, at the present time, alternative fuel costs are higher than petroleum-based fuels. Engine manufacturers cannot show an adequate return on investment for developing alternative fuel technology.

Q167. Please describe the Johns Hopkins Advanced Natural Gas Vehicle, and provide both DOE and private sector funding during its development.

A167. The Advanced Natural Gas Vehicle is a GEO Prism that operates with a replacement engine tailored to natural gas, incorporates chassis and rear-suspension modifications to increase undercarriage space for fuel storage, uses lightweight, all composite CNG tanks arranged into fuel storage assemblies, and uses specially designed run-flat tires. The integrated design of the vehicle has enabled the prototype to demonstrate a driving range of over 300 miles in city/highway driving, performance on par with gasoline vehicles, adequate trunk space, and ultra-low exhaust emissions.

Funding Source	Program Funding
DOE	$700,000
Private Sector Funding:	
PG&E	$20,000
Washington Gas	$20,000
Gas Research Institute	$500,000
Southern Cal Gas	$200,000
Subtotal, Private Sector	$740,000
Total Program Funding	$1,440,000

Q168. On page 279 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* it is stated that 1997 planned DOE accomplishments includes the demonstration of "advanced CNG storage systems in current model Chrysler sedan and minivan that will extend their range and improve their safety. . ." and introduction of a commercially competitive dedicated Chrysler propane sedan and Ford E-95 sedan which meet ULEV standards."

Q168a. Please provide details on both DOE and private sector funding for each during the period of development.

A168a. The following table provides the information requested:

Program	DOE Funding	Private Sector Funding
Chrysler sedan	$1,100,000	None
Minivan	$750,000	$590,000
Chrysler propane sedan	$768,000	$256,000
Ford E-95 sedan	$1,269,000	None
Total	$3,887,000	$846,000

Q168b. Please explain why the U.S. taxpayers should fund these activities.

A168b. By funding these programs, the Department of Energy is developing advanced compressed natural gas (CNG) storage methods that will increase the range of CNG vehicles and lower the cost of these vehicles to the U.S. taxpayer. The propane and E-95 projects on alternative fuel vehicles that meet ultra-low emission vehicle (ULEV) standards have developed components that will help increase the level of alternative fuel technology available to the public and make alternative fuel vehicles more competitive with conventionally fueled vehicles.

Q169. Please provide a listing of the recipients of (i) the $7,681,000 in funding in FY 1995, (ii) the $6,184,000 in FY 1996 funding, and (iii) the requested level of $7,110,000 in FY 1997 for Alternative Fueled Vehicle Systems Optimization.

Q170. For each recipient of Alternative Fueled Vehicle Systems Optimization funds identified in the response to question 169 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

Q171. For those Alternative Fueled Vehicle Systems Optimization funding recipients identified in the response to question 169 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A169, A170, and A171. The following table provides the information requested (In thousands of $):

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive (Y/N)**
1	National Renewable Energy Laboratory	0	0	0	N(a)
2	Southwest Research Institute-Ethanol ULEV	0	---	---	Y
3	Impco Technologies, Inc.	60	0	—	Y
4	Southwest Research Institute ULEV School Bus	1,000	500	500	Y
5	Rutgers University	0	0	---	N(b)
6	Colorado School of Mines	0	0	0	N(b)
7	Thiokol Corporation	72	0	---	Y
8	Arthur D. Little, Inc.	0	0	---	Y
9	Acurex Environmental Corporation	0	0	---	Y
10	The Adept Group	2,000	0	---	N(b)
11	AVL Powertrain	100	200	---	Y
12	ThermoTech	75	---	---	N(b)
13	Caterpillar	440	450	---	Y
14	New University RFP	—	0	0	Y
15	New Natural Gas Storage	—	0	0	Y
16	New Med Duty RFP	—	400	500	Y
17	Diesel Cycle Alcohol Fueled Engines RFP	—	—	0	Y
18	Increased Efficiency Alcohol Vehicle	—	—	0	Y
19	Light Duty DME Vehicle RFP	—	—	0	Y
20	Automotive Components Evaluation and Integration RFP	—	---	0	Y
21	New Alcohol Vehicle Technology Integration RFP	—	0	---	Y
22	Oak Ridge National Laboratory	300	0	100	N(a)
23	Detroit Diesel Corporation	25	55	30	Y
24	Thermo Power Corporation, Tecogen Division	0	0	---	N(b)
25	Caterpillar, Inc.	75	20	---	N(b)
26	University of Tennessee	0	—	---	N(c)

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
27	New/US Engine Companies	—	30	240	Y
28	Massachusetts Institute of Technology	0	0	0	N(c)
29	Johns Hopkins University Applied Physics Laboratory/U.S. Navy	0	0	0	N(b)
30	BDM Oklahoma	0	0	—	N(b)
31	University of Oklahoma	0	—	—	N(c)
32	Baylor University/Governor's Ethanol Coalition	0	0	0	N(c)
33	Southwest Research Institute/ USA Rail Consortium	1,680	1,100	1,300	N(d)
34	Atlanta Gas Light Adsorbent Research Group	527	125	—	Y
35	Thiokol Corporation	0	0	—	Y
	Total	6,354	2,880	2,670	

Footnotes:

(a) Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

(b) Company possesses unique capabilities.

(c) University, non-competitive grant.

(d) Unsolicited proposal; the sole source justification was based on unique capabilities.

Q172. Please provide a listing of the recipients of (i) the $1,980,000 in funding in FY 1995, (ii) the $994,000 in FY 1996 funding, and (iii) the requested level of $840,000 in FY 1997 for Alternative Fueled Vehicle Atmospheric Reactions.

Q173. For each recipient of Alternative Fueled Vehicle Atmospheric Reactions funds identified in the response to question 172 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

Q174. For those Alternative Fueled Vehicle Systems Atmospheric Reactions funding recipients identified in the response to question 172 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A172, A173, and A174. The following table provides the information requested (In thousands of $):

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
1	National Renewable Energy Laboratory	0	0	0	N(a)
2	Coordinating Research Council	330	220	150	Y(b)

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
3	University of Dayton Research Institute	0	0	---	Y
4	Southwest Research Institute	0	0	---	Y
5	Systems Applications International	0	0	0	Y
6	Radian Corporation	0	---	---	Y
7	Oak Ridge National Laboratory/ IEA	0	0	0	N(a)
8	Environmental Protection Agency (IAG)	280	150	150	N (c)
9	Heavy Vehicle Emissions RFP	---	---	0	Y
	Total	610	370	300	

Footnotes:

(a) Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

(b) A cost-share subcontract was placed with the Coordinating Research Council to cooperatively support projects of common interest, but nearly all projects funded through the Coordinating Research Council are selected on a competitive basis.

(c) The EPA funding is based on an Interagency Agreement which includes facilities and personnel support by EPA.

Q175. Please provide a listing of the recipients of (i) the $11,518,000 in funding in FY 1995, (ii) the $9,973,000 in FY 1996 funding, and (iii) the requested level of $5,493,000 in FY 1997 for Alternative Fueled Vehicle Data Acquisition.

Q176. For each recipient of Alternative Fueled Vehicle Data Acquisition funds identified in the response to question 175 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

Q177. For those Alternative Fueled Vehicle Data Acquisition funding recipients identified in the response to question 175 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A175, A176, and A177. The following table provides the information requested (In thousands of $):

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
1	Argonne National Laboratory	0	0	0	N(a)
2	Tinker and Vance Air Force Base/BDM Oklahoma Support	0	0	---	N(b)
3	State Energy Offices	1,112	1,200	800	Y
4	National Renewable Energy Laboratory (NREL)	0	0	0	N(a)

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
5	NREL-Alternative Fuels Data Center	0	0	0	N(a)
6	Dwights Energy Data, Inc.	0	0	0	N(b)
7	Analysts, Inc.	0	0	---	Y
8	Natural Gas Vehicle Technology Center	122	---	---	N(b)
9	Battelle Memorial Institute-Ethanol Eval	300	---	---	N(b)
10	Various Heavy-Duty Demonstrations	667	361	---	N(b)
11	Battelle Memorial Institute-Federal Express CleanFleet	1,060	---	---	N(b)
12	Kelly Striebig	20	---	---	N(b)
13	Battelle Memorial Institute-National Park Service	0	0	--	N(b)
14	Battelle Memorial Institute-Bus Program	0	0	0	N(b)
15	Battelle Memorial Institute-Heavy-Duty Evaluations	0	---	---	N(b)
16	ManTech Environmental Technology, Inc.	0	0	---	Y
17	Environmental Research and Development	0	0	---	Y
18	Automotive Testing Laboratories	0	0	---	Y
19	Compressed Gas Technologies, Inc.	0	0	---	Y
20	Phillips 66 Company	0	0	---	Y
21	Trucking Research Institute	282	282	---	N(b)
22	Antares Group	0	---	---	N(b)
23	Great Lakes Marketing	0	---	---	N(b)
24	Driving Cycles RFP	0	0	---	Y
25	Clean Corridor RFP	110	---	---	N(b)
26	Light-Duty Focus Fleet RFP	---	0	0	Y
27	Light-Duty Vehicle Evaluation RFP	---	0	---	Y
28	Medium-Duty Study RFP	---	0	---	---
29	Vehicle Evaluations RFP	---	0	---	Y
30	Heavy-Duty Evaluation Program RFP	---	---	0	Y
31	Medium/Heavy-Duty Program RFP	---	---	0	Y
32	HD Demonstration Sites RFP	---	---	0	Y
33	Medium-Duty RFP	---	---	0	Y
34	Clean Cab Company	0	0	---	N(b)
35	West Virginia University-Heavy Duty Dyno	0	0	0	N(c)
36	West Virginia University-National Center for Alternative Fuels	0	0	0	N(c)
37	Gas Technology Canada	---	100	100	Y
38	Biodiesel RFP	---	100	100	Y
	Total	**3,673**	**2,043**	**1,200**	

Footnotes:

(a) Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

(b) Company possesses unique capabilities.

(c) University, non-competitive grant.

Q178. Please provide a listing of the recipients of (i) the $1,500,000 in funding in FY 1995, (ii) the $850,000 in FY 1996 funding, and (iii) the requested level of $930,000 in FY 1997 for Alternative Fueled Vehicle Student Competitions.

A178. Most of the several dozen recipients of funding for student vehicle competitions are small providers of goods and services. Examples of these of goods and services include tents, data collection meters, memory modules, photography services, safety equipment, portable toilets, conference room rental, insurance, trophies, satellite video news release, printed materials, etc. Each of these providers received less than $11,000. Schools and universities are the largest recipients, but as the response to question 179 shows, they provide a significant cost share. Identified in Table 1 are the largest recipients of DOE student competition funds for the years requested. What does not appear in the table are the many dozen contributors to student competitions who receive no DOE dollars, but who donate substantial sums. Therefore, Table 2 is included to show all major contributors to the student vehicle competitions.

Table 1. Recipients of DOE Student Vehicle Competition Funds (In thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive (Y/N)**
1	Universities	144	120	150	Y
2	Argonne National Laboratory	795	670	685	N
3	National Renewable Energy Lab.	200	55	100	N
4	Northeast Sustainable Energy Association	40	50	40	N
5	International Electric Grand Prix Association	30	0	0	N
6	Reynolds Communications	80	0	0	N
7	Cruising Equipment	101	0	0	N*
8	Miscellaneous	63	TBD	TBD	N
	Total	**1,453**	**TBD**	**TBD**	

*Although this procurement was not competitive in FY 1995, it was a follow on to an FY 1994 competitive award.

Table 2. Contributors to DOE-Sponsored Student Vehicle Competitions (In thousands of $).

Major Contributors	**FY 1995**	**FY 1996**	**FY 1997**	**Total**
Universities	2,261	1,490	780	4,531
Chrysler	701	100	TBD	801
USCAR	100	602	800	1,502
Detroit Edison	100	100	100	300
Natural Resources Canada	29	0	30	59

Major Contributors	FY 1995	FY 1996	FY 1997	Total
U.S. EPA	0	100	100	200
Northeast Alt. Vehicle Consortium	50	50	50	150
NY Dept. of Environmental Protection	0	50	0	50
NJ Dept. of Transportation	0	50	0	50
NY Power Authority	0	50	0	50
Baltimore Gas & Electric	0	50	0	50
Goodyear Tire	0	100	100	200
Others ($25,000 or less)	326	150	TBD	476
Total	3,567	2,892	TBD	8,419

Q179. For each recipient of Alternative Fueled Vehicle Student Competitions funds identified in the response to question 178 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A179. See the answer to question 178. Also note that in FY 1995, DOE provided approximately 29 percent of the funds spent on student vehicle competitions. In FY 1996, the DOE share will be approximately 25 percent.

Q180. For those Alternative Fueled Vehicle Student Competitions funding recipients identified in the response to question 178 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A180. See the answer to question 178. Laboratory funding (No. 2 and 3) is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory. The awards to the Northeast Sustainable Energy Association, the International Electric Grand Prix Association, Reynolds Communications, and Cruising Equipment, Inc. were based on submission of unsolicited proposals; the sole source justifications were based on unique capabilities and previous experience.

Q181. Please provide a listing of the recipients of (i) the $21,235,000 in funding in FY 1995, (ii) the $11,002,000 in FY 1996 funding, and (iii) the requested level of $10,930,000 in FY 1997 for Alternative Fueled Vehicle Deployment for each of Investment/Alternative Fuels, Energy Policy Act Implementation, Electric Vehicle Field Operations, and AFV Data Acquisition.

Q182. For each recipient of Alternative Fueled Vehicle Deployment funds identified in the response to question 181 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A181 and A182. The following table provides the information requested (In thousands of $):

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
1	NREL			TBD	N
2	ANL			TBD	N
3	ORNL			TBD	N
4	INEL			TBD	N
5	U.S. Postal Service	4,000	3,000	TBD	N
6	EE Regional Support Offices			TBD	N
7	Pennsylvania	502		TBD	Y
8	Kentucky	845		TBD	Y
9	Wisconsin	1,900		TBD	Y
10	Texas	240		TBD	Y
11	New York	345		TBD	Y
12	Minnesota	26		TBD	Y
13	Nebraska	487		TBD	Y
14	Colorado	1,000		TBD	Y
15	Illinois	55		TBD	Y
16	Oregon	1,350		TBD	Y
17	California	200		TBD	Y
18	Nevada	81		TBD	Y
19	Florida	30		TBD	Y
20	District of Columbia	67		TBD	Y
21	Massachusetts	70		TBD	Y
22	New Mexico	69		TBD	Y
23	Ohio	550		TBD	Y
24	New Jersey	252		TBD	Y
25	Indiana	0		TBD	Y
26	National Automotive Technician Education Foundation	500	500	TBD	Y
27	American Automobile Association	200	200	TBD	N
28	EA Engineering and Technology			TBD	Y
29	Abacus Technology Corp.			TBD	Y
30	City and County of Denver, Colorado		250	TBD	N
31	Interstate Clean Transportation Corridor		450	TBD	N
32	Information Resources Inc.	50		TBD	N
33	Clean Air Group of Atlanta		50	TBD	N
34	West Virginia NGV Coalition		10	TBD	N
35	Governors' Ethanol Coalition	1,000	2,000	TBD	N
36	California NGV Coalition		80	TBD	N
37	Northeast States for Coordinated Air Use Management		100	TBD	N
38	Arizona Public Service	552	700	TBD	Y
39	Kansas State University	139		TBD	Y
40	Los Angeles Department of Water & Power	70		TBD	N
41	Orcas Power & Light	9		TBD	Y
42	Pacific Gas & Electric	10		TBD	Y
43	Pepco Power Company	49		TBD	N
44	Platte River Power Authority	45		TBD	Y
45	Southern California Edison	90		TBD	Y

No.	Major Recipient	Cost-Share			Competitive (Y/N)
		FY 1995	FY 1996	FY 1997	
46	Texas A&M Engineering Experimental Station	0		TBD	Y
47	University of South Florida	0		TBD	Y
48	York Technical College	3		TBD	Y
	Total	**14,786**	**7,315**	**TBD**	

Q183. For those Alternative Fueled Vehicle Data Deployment funding recipients identified in the response to question 181 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A183. See the answer to questions 181 and 182. Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurement for the management of each laboratory. Support service contracts for the program are selected through competitive procurement. Grants to States for alternative fuel and vehicle projects are based on competitive evaluation of State submitted proposals. Other recipients under Alternative Fuel Vehicle Deployment are diverse groups that are selected from unsolicited proposals; sole source justification, when needed, was based on unique capabilities.

Electric Drive Vehicle Technologies

Q184. Page 289 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Electric Vehicle R&D program:

	2000	2010	2020
Primary Energy Displaced (Quads)	**0.02**	**0.21**	**0.17**
Primary Oil Displaced (MBPD)	**0.01**	**0.13**	**0.10**
Energy Cost Savings ($B)	**0.13**	**2.01**	**1.61**
Carbon Reductions (MMTons)	**0.00**	**0.44**	**0.45**

Q184a. Please provide detailed documentation of these claimed benefits.

A184a. To estimate the market impact of electric vehicle research and development, estimations of fuel and vehicle attributes were made for conventional and advanced technologies[1]. These estimations were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations[2]. Market penetrations were put into the Integrated Market Penetration and

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Fulton, Lewis M. "Alternative-Fuel Vehicles and The Energy Policy Act: A Case Study in Technology Policy." Diss. U. of Pennsylvania, 1994.

Anticipated Cost of Transportation Technologies (IMPACTT) model[1]. The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization (miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using AVS 8.1, it was estimated that electric drive light duty vehicles would enter the market in 2000. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings and carbon reductions of these technologies.

Electric Vehicles	2000	2010	2020
Market Penetration	2.5%	2.9%	2.5%
Percent of Total Light Duty Vehicles	0.2%	3.0%	2.8%
Alternative Fuel Used (MBPD)*	0.01	0.10	0.08
Gasoline Displaced (MBPD)	0.01	0.13	0.10
Energy Cost Savings (Billions of $)	0.13	2.00	1.61
Carbon Reductions (MMTons)	-0.06	0.44	0.45

*Million Barrels per Day, equivalent to oil on a Btu basis.

Q184b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A184b. Some of the estimated benefits for the Electric Vehicle R&D program would occur if DOE funding were stopped. The major auto companies are producing electric vehicles that will go into service in California in limited numbers over the next two years. The nickel metal-hybrid battery has been given enough of a push by the USABC that it will probably be developed if DOE funds stopped, albeit at a later date than assumed to obtain the electric vehicle estimated benefits shown as being associated with the DOE program. Therefore, perhaps half of the year 2000 benefits would occur if the DOE funding were stopped; but most of the year 2010 benefits would probably not be realized if DOE funding stopped.

Q185. Page 289 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Hybrid Vehicle R&D program:

	2000	2010	2020
Primary Energy Displaced (Quads)	0.00	1.05	1.74
Primary Oil Displaced (MBPD)	0.00	0.49	0.82
Energy Cost Savings ($B)	0.00	11.53	18.91
Carbon Reductions (MMTons)	0.00	20.27	33.80

Q185a. Please provide detailed documentation of these claimed benefits.

A185a. To estimate the market impact of hybrid vehicle research and development, estimations of fuel and vehicle attributes were made for conventional and advanced technologies[1]. These estimations were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations[2]. Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model[3]. The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization (miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

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[1] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ESD/TM-93), Argonne National Laboratory, Argonne, IL, December 1994.

Using AVS 8.1, it was estimated that hybrid light duty vehicles would enter the market in 2000. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings and carbon reductions of these technologies.

Hybrid Vehicles	2000	2010	2020
Market Penetration	0.0%	27.6%	26.4%
Percent of Total Light Duty Vehicles	0.0%	13.4%	24.8%
Alternative Fuel Used (MBPD)*	0.00	0.00	0.00
Gasoline Displaced (MBPD)	0.00	0.49	0.82
Energy Cost Savings (Billions of $)	0.00	11.53	18.91
Carbon Reductions (MMTons)	0.00	20.27	33.80

*Million Barrels per Day, equivalent to oil on a Btu basis.

Q185b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A185b. If the DOE funding for hybrid vehicles were stopped today, it is very probable that none of the estimated benefits from hybrid vehicles would be realized. If the DOE contracts with the "Big Three" domestic auto companies were dropped, it is very likely that hybrid R&D by these companies, aimed at a double fuel economy hybrid vehicle, would come to a near standstill. If the Partnership for a New Generation of Vehicles program were dropped, the work being done to design and produce a three-times fuel economy hybrid vehicle would cease.

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Fulton, Lewis M. "Alternative-Fuel Vehicles and The Energy Policy Act: A Case Study in Technology Policy." Diss. U. of Pennsylvania, 1994.

[3] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ESD/TM-93), Argonne National Laboratory, Argonne, IL, December 1994.

Q186. Page 290 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for the Fuel Cell R&D program:

	2000	2010	2020
Primary Energy Displaced (Quads)	0.00	0.08	0.82
Primary Oil Displaced (MBPD)	0.00	0.04	0.39
Energy Cost Savings ($B)	0.00	0.84	8.90
Carbon Reductions (MMTons)	0.00	2.11	20.91

Q186a. Please provide detailed documentation of these claimed benefits.

A186a. To estimate the market impact of fuel cell vehicle research and development, estimations of fuel and vehicle attributes were made for conventional and advanced technologies[1]. These estimations were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations[2]. Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model[3]. The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization (miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using AVS 8.1, it was estimated that fuel cell light duty vehicles would enter the market in 2000. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings and carbon reductions of these technologies.

Fuel Cell Vehicles	2000	2010	2020
Market Penetration	0.0%	3.9%	13.7%
Percent of Total Light Duty Vehicles	0.0%	0.7%	8.4%
Alternative Fuel Used (MBPD)*	0.00	0.00	0.00
Gasoline Displaced (MBPD)**	0.00	0.03	0.39
Energy Cost Savings (Billions of $)	0.00	0.84	8.90
Carbon Reductions (MMTons)	0.00	2.11	20.90

*See Biofuels for alternative fuel use.

**Includes gasoline displaced from efficiency improvements only. Gasoline displaced from the use of alternative fuels is shown in biofuels.

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Fulton, Lewis M. "Alternative-Fuel Vehicles and The Energy Policy Act: A Case Study in Technology Policy." Diss. U. of Pennsylvania, 1994.

[3] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ESD/TM-93), Argonne National Laboratory, Argonne, IL, December 1994.

Q186b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A186b. The estimated benefits for the fuel cell program do not amount to much until near the 2020 period. This illustrates the long-term nature of this technology. If DOE funding were dropped, the small amount of fuel cell research that would remain would probably not bring any benefits until after 2030, if even then.

Q187. On page 291 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* it is stated that 1997 planned DOE accomplishments includes the completion of "laboratory test on long-term lithium batteries, to enable industry to evaluate in-vehicle operation."

Please provide both DOE and private sector funding for these tests, by performer.

A187. The estimated costs of such a test is about $50,000. These costs would be shared by government and industry (45/55) as anticipated by the USABC Phase 1 agreement. The tests are planned to be done at the Idaho National Engineering Laboratory.

Q188. Please provide a listing of the recipients of (i) the $25,835,000 in funding in FY 1995, (ii) the $18,468,000 in FY 1996 funding, and (iii) the requested level of $17,820,000 in FY 1997 for Electric Vehicle R&D.

Q189. For each recipient of Electric Vehicle R&D funds identified in the response to question 188 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A188 and A189. The following table provides the information requested (In thousands of $):

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
1	Advanced Battery Development-U.S. Advanced Battery Consortium	20,760	18,320	18,110	Y
2	Exploratory Research-Lawrence Berkeley Laboratory and other National Laboratories, universities, and small businesses	0	0	0	Y
3	Program Support	0	0	0	Y
	Total	20,760	18,320	18,110	

Q190. For those Electric Vehicle R&D funding recipients identified in the response to question 188 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A190. See the answer to questions 188 and 189. All funds for the Electric Vehicle R&D program are awarded on a competitive basis. The United States Advanced Battery Consortium selects its subcontractors on a competitive basis. Awards in the Exploratory Research program are selected competitively by the DOE program office in consultation with the USABC. Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

Q191. Please provide a listing of the recipients of (i) the $45,492,000 in funding in FY 1995, (ii) the $53,313,000 in FY 1996 funding, and (iii) the requested level of $81,650,000 in FY 1997 for Hybrid Vehicle R&D for each of Hybrid Propulsion Systems, PNGV: Power Unit R&D, PNGV: High Power Energy Storage, and PNGV: High Power Semiconductor Controls.

Q192. For each recipient of Hybrid Vehicle R&D funds identified in the response to question 191 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A191 and A192. The following table provides the information requested (In Thousands of $):

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
1	**Hybrid Propulsion Systems**				
	a. General Motors Team	21,056	19,227	16,648	Y
	b. Ford Team	6,812	18,669	17,406	Y
	c. Chrysler Team	n/a	4,900	13,500	N
	d. NREL	0	0	0	N
	Subtotal	27,868	42,796	47,554	
2	**Power Unit R&D**				
	a. Allison Engine Company	530	600	860	Y
	b. AlliedSignal	890	690	630	Y
	c. NASA	0	0	0	N
	Subtotal	1,420	1,290	1,490	
3	**High Power Energy Storage**				
	a. USABC	900	6,189	10,500	Y
	b. LBL	0	0	0	N
	c. LLNL	0	0	0	N
	d. INEL	0	0	0	N
	Subtotal	900	6,189	10,500	
4	**High Power Semiconductor**				
	a. Harris Semiconductor	0	0	0	Y
	b. ORNL	0	0	0	N
	c. SNL	0	0	0	N
	Subtotal	0	0	0	
	Total	**30,188**	**50,275**	**59,544**	

Q193. For those Hybrid Vehicle R&D funding recipients identified in the response to question 191 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A193. See the answer to questions 191 and 192. With regard to item 1.c. in the above table, on March 1, 1996, the Office of Transportation Technologies (OTT) signed an $84.4 million subcontract with Chrysler Corporation. The subcontract is four years, 50-50 cost shared, and awarded on a non-competitive basis. Prior to March 1, 1996, the Department's Hybrid Vehicle Program included two development subcontracts with teams headed by General Motors Corporation and Ford Motor Company. These two subcontracts resulted from a competitive Hybrid Vehicle Program solicitation. The addition of Chrysler Corporation, the only remaining non-participating major domestic automobile manufacture that could comply with all the solicitation requirements, is considered an important program element by both the government and private sector parties. Chrysler's involvement will ensure that all three of the hybrid propulsion system development efforts will be carried out by competitive teams led by domestic automotive industry organizations. This not only heightens the development process, but also allows the development of a broader supplier base from which the auto industry can develop partnerships.

With regard to the non-competitive awards to Laboratories in items 1d, 2c, 3b, 3c, 3d, 4b, and 4c, Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

With regard to item 4a, Harris Semiconductor is a major partner with the Navy Department in the development of Power Electronic Building Blocks (PEBB). Harris was awarded a competitive contract through the Navy under a 6.2 funding category which does not require cost sharing. Although the Harris contract is not cost-shared, the DOE funding supporting the Harris contract is highly leveraged through the Navy contract. Additional PEBB monies are being provided through other DOD funding sources to support competitive cost-shared contracts for systems development.

Q194. Please provide a listing of the recipients of (i) the $22,221,000 in funding in FY 1995, (ii) the $21,512,000 in FY 1996 funding, and (iii) the requested level of $30,150,000 in FY 1997 for Fuel Cell R&D for each of PNGV: Fuel Cell Vehicles and PNGV: Fuel Cell Development.

Q195. For each recipient of Fuel Cell R&D funds identified in the response to question 194 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A194 and A195. The following table provides the information requested (In Thousands of $):

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive (Y/N)**
1	General Motors Team	1,300	1,375	TBD	Y
2	Ford Team	720	875	TBD	Y
3	Pentastar/Chrysler Team	1,090	1,125	TBD	Y
4	H Power Team	430	0	0	Y

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
5	Arthur D. Little, Inc.	375	0	0	Y
6	PRDA: Texas A&M University International Fuel Cells Energy Partners Arthur D. Little, Inc. Vairex Corporation AlliedSignal	230	390	0	Y
7	Integrated Fuel Cell Stack System: Contractor(s) TBD	0	0	TBD (20%)	Y
8	Multi-Fuel Reforming System: Contractor(s) TBD	0	0	TBD (20%)	Y
9	SBIR Grants: TDA Research Lynntech Inc. ElectroChem ICET Inc. Arcanum Corporation	None	0	TBD (None)	Y
10	STTR Grants: Contractor(s) TBD	n/a	TBD (None)	TBD (None)	Y
11	Laboratories: Los Alamos Argonne Brookhaven Lawrence Berkeley Lawrence Livermore National Renewable Energy Laboratory	0	0	0	N
	Total	4,145	3,765	TBD	

Q196. For those Fuel Cell R&D funding recipients identified in the response to question 194 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A196. See the answer to questions 194 and 195. All DOE contract awards were competitive. Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

Q197. On page 300 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The fuel cell program will be realigned into a single effort consisting of projects coordinated through the Fuel Cell Alliance."

Q197a. Please describe the Fuel Cell Alliance and identify its members, and costs of membership in the alliance.

A197a. The National Fuel Cell Alliance is the new programmatic operating strategy that DOE is implementing to manage its transportation fuel cell research and development programs. The reason for establishing the Fuel Cell Alliance is to better coordinate and maximize sharing of government-supported, pre-competitive fuel cell research and development for transportation applications. The expected benefits resulting from this Alliance approach are: a greater return for the Government's R&D investment; a more direct mechanism for addressing the needs and concerns of customers and stakeholders while upholding DOE's responsibility for carrying out the program; and maintaining U.S. competitiveness in the face of rapidly increasing investments in the technology by foreign governments and industries.

There is no "membership," and there are no costs associated with participating in the Alliance. Participation in this U.S. public/private partnership is voluntary and is *not* limited to those organizations that are under contract to DOE; participation is open to all organizations who want to cooperate with the Department to advance the development of fuel cells for transportation applications. Fuel cell developers, fuel providers, small businesses, universities, National Laboratories, domestic automakers, and government agencies will participate in the National Fuel Cell Alliance.

Q197b. Please describe the contractual or other formal legal instruments currently existing between the DOE and the Fuel Cell Alliance, including cost-sharing and intellectual property agreements.

A197b. Unlike the U.S. Advanced Battery Consortium, there is no contractual or other formal legal relationship between DOE and the National Fuel Cell Alliance. The Alliance functions by communicating and coordinating; it provides a forum for input from stakeholders and customers, and provides DOE with a mechanism to address their concerns.

Under the National Fuel Cell Alliance, many of the participating organizations (e.g., fuel cell developers, small businesses. etc.) will be under direct contract to DOE to perform research and development. Additionally, however, other organizations (such as the U.S. Council for Automotive Research, State and local government agencies, and fuel providers) participate in the Alliance, working in true partnership with DOE to advance commercialization of fuel cells. Cost sharing by DOE contractors will continue to be approximately 20 percent or greater for fuel cell research and development. As shown above the National Laboratories provide no cost share. As the technology matures, contractor, cost share is expected to increase.

Intellectual property rights under the Alliance will be negotiated between the government and the contractor. Small businesses that are under contract to DOE retain intellectual property. DOE usually allows the contractor to own the intellectual property rights when significant cost share is involved (usually 20 percent). It is expected that intellectual property rights under the Alliance would favor suppliers and developers. Under the current program management system, suppliers and developers are under subcontract to system developers and intellectual property is negotiated under the terms of the subcontract. Under the Alliance, there are no special arrangements or deals between system developers and suppliers/developers regarding intellectual property for government supported R&D. The original equipment manufacturers (OEMS) have the right to license or to buy technology from the suppliers; however, this occurs outside the Alliance.

Q197c. Please describe how the fuel cell program will be coordinated through the Fuel Cell Alliance.

A197c. Under the National Fuel Cell Alliance, DOE will contract directly with fuel cell developers, fuel providers, small businesses, universities, National Laboratories, and domestic automakers to carry out fuel cell research and development. Each of these organizations will perform research and development, system design and analyses, and other activities that are unique in approach and/or subject area so that duplication of effort does not occur. DOE, in cooperation with the U.S. Council for Automotive Research (USCAR), will establish R&D priorities for automotive applications. The role of USCAR will also include establishing automotive technology milestones (e.g., cost, size, weight, etc.) and assisting DOE in technical progress reviews. DOE will perform program management and procurement functions.

Currently, the majority of the DOE transportation fuel cell R&D is being carried out by the three system development teams (General Motors, Ford, and Chrysler-Pentastar). Under the new programmatic strategy implemented through the Alliance, projects will be more streamlined allowing DOE to reduce any potential duplication of efforts that would occur if each system development team addressed common fuel cell development barriers.

Q197d. Will only projects proposed by the Fuel Cell Alliance be considered for funding? What is the process to ensure competition?

A197d. The Department of Energy has overall program management responsibility for the transportation fuel cell systems R&D. Association with the Alliance has no bearing on which organizations receive DOE funding. DOE will determine which projects are funded through competitive procurements and will continue to follow Federal procurement regulations to ensure fair and open competition.

Transportation Materials Technologies

Q198. Page 307 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits for Lightweight Vehicle Materials:

	2000	2010	2020
Primary Energy Displaced (Quads)	**0.00**	**0.18**	**0.21**
Primary Oil Displaced (MBPD)	**0.00**	**0.09**	**0.10**
Energy Cost Savings ($B)	**0.00**	**2.04**	**2.24**
Carbon Reductions (MMTons)	**0.00**	**3.59**	**4.00**

Q198a. Please provide detailed documentation of these claimed benefits.

A198a. To estimate the market impact of lightweight vehicle material research and development, estimations of fuel and vehicle attributes were made for conventional and advanced technologies[1]. It is assumed that the lightweight vehicle would be represented by an

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For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals s stated by the Office of Transportation Technologies.

aluminum intensive vehicle. Estimations of the attributes of this type of vehicle were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations[1]. Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model.[2]. The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization (miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using AVS 8.1, it was estimated that lightweight aluminum intensive vehicles would enter the market in 2002. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings and carbon reductions of these technologies.

Light Weight Vehicles	2000	2010	2020
Market Penetration	0.0%	11.5%	9.9%
Percent of Total Light Duty Vehicles	0.0%	7.6%	10.0%
Alternative Fuel Used (MBPD)*	0.00	0.00	0.00
Gasoline Displaced (MBPD)	0.00	0.09	0.10
Energy Cost Savings (Billions of $)	0.00	2.04	2.24
Carbon Reductions (MMTons)	0.00	3.59	4.01

*Million Barrels per Day, equivalent to oil on a Btu basis.

Q198b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

Q198b. The lightweight materials estimated benefits result from some conventional light vehicles becoming lighter by 30 percent. This is a very ambitious weight reduction goal that would probably not be fully realized without DOE support. However, auto manufacturers may take some weight out of conventional vehicles if they are pushed by regulations to do so or if weight reduction accomplishes some other goal, such as increasing performance.

Q199. On page 315 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The U.S. Automotive Materials Partnership and the PNGV Materials Technical Team will collaboratively set technical targets and jointly establish R&D priorities with DOE."

Q199a. Please describe the (i) U.S. Automotive Materials Partnership, and (ii) PNGV Materials Technical Team, including identification of membership and costs of membership.

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[1] Fulton, Lewis M. "Alternative-Fuel Vehicles and the Energy Policy Act: A Case Study in Technology Policy." Diss. U. of Pennsylvania, 1994.

[2] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ESD/TM-93), Argonne National Laboratory, Argonne, IL, December 1994.

A199a. The U.S. Automotive Materials Partnership (USAMP) is a consortium of Chrysler, Ford, and General Motors organized in 1993, and is one of 13 consortia under the auspices of the U.S. Counsel for Automotive Research (USCAR). The USAMP mission is to define and conduct vehicle-related R&D in materials and materials processing which will improve the competitiveness of the U.S. automotive industry. USAMP goals are to develop several families of automotive materials that will impact strategic needs of the industry. These needs include improved fuel economy through vehicle weight reduction, improved reliability, reduced emissions, improved safety and vehicle crashworthiness, lower cost processing, rapid prototyping, environmentally benign manufacturing, and recycling.

USAMP has no employees, and its activities are directed by a Steering Committee made up of two representatives each from Chrysler, Ford, and General Motors and the chairmanship rotates from company to company on an annual basis. USAMP is subdivided into six divisions plus a special activities group assigned to study life cycle analysis. Each division is responsible for interacting with an appropriate group of suppliers, universities, and other professional associations, and for attempting to develop advanced lightweight materials projects. The six divisions are: the Automotive Composites Consortium (ACC), The Light Metals Division, the Engineering Plastics Division, the Steel and Cast Iron Division, the Ceramics Division, and the Advanced Metals Division.

The cost of membership in USAMP consists primarily of an in-kind match provided by USAMP participants. Budgets for each division are established as needed to cover its research; only the ACC has a minimum funding requirement. This amount is not normally published, but it is interesting to note that all members contribute more than the minimum requirement.

The Partnership for a New Generation of Vehicles (PNGV) Materials Technical Team is part of the industry-government partnership, and works closely with USAMP to ensure coordination and communication between all partners. The Materials team cross cuts the PNGV powertrain teams and the other cross cutting teams (Manufacturing and Systems Analysis) to ensure needed materials development is carried out.

Membership of the PNGV Materials Technical Team consists of two representatives each from Chrysler, Ford, and General Motors, as well as four government representatives. There is no cost of membership except for the contribution of time and travel costs of the members.

Q199b. Please describe the contractual or other formal legal instruments currently existing between the DOE and (i) the U.S. Automotive Materials Partnership, and (ii) PNGV Materials Technical Team, including cost-sharing and intellectual property agreements.

A199b. DOE and USCAR entered into a Protocol on December 3, 1993, that provided a framework for the performance of various cooperative programs with the partnerships under USCAR, such as USAMP. A special U.S. competitiveness provision was negotiated for use by the Department and its Laboratories in agreements, e.g., CRADAs, cooperative agreements, cost-shared subcontracts, etc., with USCAR. As a condition of the Waiver of Government Patent Rights, which was requested by USAMP and granted by DOE, USAMP agreed to the U.S. competitiveness provision of the USCAR Master CRADA. Additionally, a special withholding of technical information authorized under Section 3001 of the Energy Policy Act of 1992 was incorporated in the cooperative agreement to ensure that USAMP has reasonable lead time to commercialize the results of the joint research.

Cooperative Agreement DE-FC05-96OR22363: Currently, there is one sole source financial assistance agreement, a cooperative agreement, between DOE and USAMP. DOE received an unsolicited proposal from USAMP in June 1994, and subsequently: (1) evaluated the application based on overall technical merit, anticipated objectives, qualifications and facilities of Chrysler, Ford, and General Motors, and innovation and uniqueness of the approach; (2) determined a cooperative agreement was the appropriate award instrument as per Public Law 95-224; (3) justified the sole source award based on the criteria as stated in the "Determination of Non-competitive Financial Assistance"; (4) made a determination of eligibility for funding under Section 2306 of the Energy Policy Act of 1992; (5) received a request for and subsequently granted a waiver of Government patent rights to inventions made under this agreement; (6) required an industry cost sharing of 50% over the life of the cooperative agreement; and (7) required that USAMP execute a commitment to promote the goal of U.S. industrial competitiveness as required under Section 2306 of the Energy Policy Act.

As part of this agreement, USAMP has and intends to award a number of subcontracts to its suppliers via competitive solicitation. USAMP negotiates intellectual property rights with these suppliers based on the magnitude of their cost share with USAMP.

CRADAs: A number of CRADAs between DOE Laboratories and the USAMP exist, all of which use the terms and conditions of the USCAR Master CRADA.

Subcontracts: USAMP participates in two subcontracts with DOE under this program. These were awarded through a Request for Proposals in 1995.

No formal agreement exists between DOE and the PNGV Materials Technical Team.

Q199c. Please describe how "[t]he U.S. Automotive Materials Partnership and the PNGV Materials Technical Team will collaboratively set technical targets and jointly establish R&D priorities with DOE".

A199c. The USAMP and DOE work jointly to define benefits and identify obstacles for potential projects, both through the PNGV Materials Technical Team and USAMP. The PNGV Materials Technical Team sets long-range goals and identifies challenges to reaching the overall objectives of PNGV.

Subsequently, USAMP selects projects to address those challenges. All potential projects are reviewed by the Joint Project Management Team, consisting of representatives from the USAMP Steering Committee, the DOE Program Manager for Lightweight Vehicle Materials, a second DOE Program Manager, appointed on a rotating basis, the DOE Operations Technical Project Manager for Materials, and a DOE Laboratory Technical Coordinator.

When it is appropriate for the National Laboratories to participate, each Laboratory is given an opportunity to demonstrate its capability in the area through a mechanism determined by the Associate Directors of the DOE National Laboratories. USAMP representatives review each Laboratory's proposal, along with those from the appropriate suppliers, and choose a team to address the research.

Q199d. Will only projects proposed by the U.S. Automotive Materials Partnership and the PNGV Materials Technical Team be considered for funding? What is the process to ensure competition?

A199d. DOE funds numerous projects outside USAMP through competitive government procurement processes. USAMP will consider funding, under the cooperative agreements, any materials program proposed by a USCAR consortium or other outside agency. Outside projects, however, would be screened and subject to the same prioritization procedure as those developed within USAMP and the Materials Technical Team, and only those which indicated sufficient merit to justify inclusion in DOE's operating budget would be accepted.

The normal approach used to select a supplier or university for contracted services or hardware is intended to ensure the desired competition. Engineers with a need for contracting with a supplier or university are expected to contact and review their needs with several qualified sources. They then solicit quotations from the better sources and evaluate their quotations on the basis of:

(1) prior experience;
(2) qualifications of the personnel involved;
(3) equipment and facilities available;
(4) how well the proposed work plan addresses stated needs;
(5) appropriateness of the proposed schedule; and
(6) proposed cost.

The best source is then awarded the subcontract.

In rare cases, where it has been established that a particular source is so well qualified for a particular job that it is unwise to consider alternative sources, justification for such action is provided in a sole-source letter. This would be true only where unique equipment or capabilities are available from a single company/university, or when prior project work provides a particularly strong background for the new work, one that would require unwarranted additional time and/or cost to develop at another source.

Q200. Please provide a listing of the recipients of (i) the $22,133,000 in funding in FY 1995, (ii) the $20,866,000 in FY 1996 funding, and (iii) the requested level of $15,860,000 in FY 1997 for Propulsion System Materials.

Q201. For each recipient of Propulsion System Materials funds identified in the response to question 200 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A200 and A201. The following table provides the information requested (In Thousands of $).

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive (Y/N)
1	Oak Ridge National Laboratory	0	0	0	N
2	Argonne National Laboratory	0	0	0	N
3	National Institute of Standards and Technology	848	450	450	N
4	Southern Illinois University	73	74	74	N
5	University of Michigan	17	11	0	N
6	AlliedSignal Ceramic Components	88	38	86	Y
7	Eaton Corporation	248	0	0	Y
8	University of Connecticut	0	0	0	N
9	Argonne National Laboratory	0	0	0	N
10	Norton Company	425	0	0	Y
11	Kyocera	397	0	0	Y
12	Golden Technologies	1,606	0	0	Y
13	S. F. Duffy	0	0	0	N
14	NASA Lewis Research Center	0	0	0	N
15	AlliedSignal Engines	222	0	0	Y
16	University of Dayton	38	39	39	Y
17	North Carolina A&T State Univ.	56	0	0	Y
18	Conference Management Associates	0	0	0	N
19	Energetics	0	0	0	Y
20	LoTEC, Inc.	0	0	0	Y
21	University of Tennessee	0	0	0	N
22	University of Massachusetts	0	0	0	Y
23	Caterpillar, Cummins, Detroit Diesel Corp., Norton, Coors, AlliedSignal, Ceradyne, Kyocera	0	666	220	Y
24	Allison Engine Company	0	300	200	Y
25	AlliedSignal Ceramics, Kyocera	420	420	360	Y
	Total	4,438	1,998	1,429	

Q202. For those Propulsion System Materials funding recipients identified in the response to question 200 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A202. See the answer to questions 200 and 201. Laboratory funding (Nos. 1, 2, and 9) is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. The National Institute of Standards and Technology (No. 3) has unique capability due to the qualifications of key personnel. Southern Illinois University (No. 4) has unique capability due to the qualifications of Dr. Dale Wittmer. The University of Michigan (No. 5) has unique capability due to the qualifications of Dr. T. Y. Tien. The University of Connecticut (No. 8) contract was based on a non-solicited proposal; the sole source justification was based on unique capabilities. Dr. S. F. Duffy (No. 13) is a uniquely qualified consultant. NASA Lewis Research Center (No. 14) has a unique, NASA-funded program for the development of a life prediction code. DOE gets significant leverage of program funds by conducting this work at NASA.

Conference Management Associates (No. 18) is uniquely qualified by means of years of experience in supporting OTT. The University of Tennessee (No. 21) provides materials science students to support R&D tasks at ORNL and is uniquely qualified due to its close proximity to ORNL.

Q203. Please provide a listing of the recipients of (i) the $11,216,000 in funding in FY 1995, (ii) the $13,286,000 in FY 1996 funding, and (iii) the requested level of $22,000,000 in FY 1997 for Lightweight Vehicle Materials for each of PNGV: Lightweight Vehicle Materials and Heavy Vehicle Materials Technology.

A203. The following table provides the information requested (In Thousands of $):

No.	Major Recipient	Cost-Share			Competitive
		FY 1995	FY 1996	FY 1997	
1	ORNL, LLNL, SNL, USAMP, American Foundryman's Society, Purdue University, Georgia Tech, PCT, Thixomat, CMI, Amcast, Thompson Aluminum Castings	1,150	1,301	1,805	N
2	ORNL, LLNL, INEL, SNL, USAMP, NADCA	1,580	1,250	2,200	N
3	ORNL, Ames Laboratory, USAMP	0	545	1,035	N
4	ASME, PNNL, INEL, ORNL, Ravenswood Aluminum, ARCO Aluminum, LANL, Commonwealth Aluminum, USAMP, GM, Reynolds Metal	700	1,200	1,300	N
	Total	3,430	4,296	6,340	

Q204. For each recipient of Lightweight Vehicle Materials funds identified in the response to question 203 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A204. See the answer to question 203. DOE and USAMP began a 50 percent cost-shared cooperative agreement (Nos. 1-4, 9) in FY 1995. Major projects in aluminum forming technology (No. 5) are cost shared between 20 and 30 percent. Laboratory CRADAs (Nos. 1-4, 6-13) are 50 percent cost shared. Other laboratory projects (Nos. 7, 8, 11, 12) were not cost-shared. Several projects will be funded in FY 1997 from a competitive solicitation by the PNGV Materials Technical Team for white papers in the areas of lightweight materials for aluminum body structures, fiber-reinforced polymer composite body structures, chassis materials, and powertrain materials. The amount of cost sharing has not yet been determined for these projects, but it is anticipated to be more than 50 percent overall.

Q205. For those Lightweight Vehicle funding recipients identified in the response to question 203 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A205. See the answer to question 203. A sole source award for a cooperative agreement (Nos. 1-4, 9) was made to USAMP in response to its unsolicited proposal. USAMP, a consortium of

USCAR, represents more than 85 percent of the U.S. automotive manufacturing industry. Therefore, this organization is uniquely qualified to develop and apply these technologies in the United States. Major projects in aluminum forming technology (No. 5) were competitively bid through a formal Request for Proposals. Awards were made on the basis of technical approach and understanding, quality of facilities, equipment, personnel, and corporate experience, and amount of cost share. Laboratory funding (Nos. 1-4, 6-13) is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Several projects will be funded in FY 1997 from a competitive solicitation by the PNGV Materials Technical Team for white papers in the areas of lightweight materials for aluminum body structures, fiber-reinforced polymer composite body structures, chassis materials, and powertrain materials.

Combustion Engine R&D

Q206. Page 320 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Light Duty Engine R&D:

	2000	2010	2020
Primary Energy Displaced (Quads)	**0.00**	**0.23**	**0.25**
Primary Oil Displaced (MBPD)	**0.00**	**0.11**	**0.12**
Energy Cost Savings ($B)	**0.00**	**2.51**	**2.69**
Carbon Reductions (MMTons)	**0.00**	**4.05**	**4.43**

Q206a. Please provide detailed documentation of these claimed benefits.

A206a. To estimate the market impact of light duty engine research and development, estimations of fuel and vehicle attributes were made for conventional and advanced technologies.[1] The advanced technologies for this analysis included advanced diesels for light duty applications. It is assumed that advanced diesels could improve light duty vehicle operating efficiency by 30%. This estimation, as well as others for cost and vehicle emissions, were put into the Alternative Vehicle Sales Model (AVS 8.1) to determine market acceptance and resulting market penetrations.[2] Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model.[3] The IMPACT-R model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Fulton, Lewis M. "Alternative-Fuel Vehicles and The Energy Policy Act: A Case Study in Technology Policy." Diss. U. Of Pennsylvania, 1994.

[3] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANL/ESD/TM-93), Argonne National Laboratory, Argonne, IL, December 1994.

(miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using AVS 8.1, it was estimated that advanced diesel engines would enter the light duty vehicle market in 2002. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings, and carbon reductions of these technologies.

Advanced Diesel Vehicles	**2000**	**2010**	**2020**
Market Penetration	0.0%	9.5%	7.5%
Percent of Total Light Duty Vehicles	0.0%	6.3%	7.9%
Alternative Fuel Used (MBPD)*	0.00	0.00	0.00
Gasoline Displaced (MBPD)	0.00	0.11	0.12
Energy Cost Savings (Billions of $)	0.00	2.51	2.69
Carbon Reductions (MMTons)	0.00	4.05	4.43

*Millions Barrels Per Day, equivalent on a Btu basis.

Q206b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A206b. The light duty engine estimated benefits result from a more efficient engine being installed in conventional vehicles (such as an advanced diesel). The auto companies might undertake such a move without DOE funding but it is less probable.

Q207. Page 321 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Heavy Duty Engine R&D:

	2000	**2010**	**2020**
Primary Energy Displaced (Quads)	**0.00**	**0.43**	**1.38**
Primary Oil Displaced (MBPD)	**0.00**	**0.20**	**0.65**
Energy Cost Savings ($B)	**0.04**	**4.19**	**13.66**
Carbon Reductions (MMTons)	**0.10**	**8.50**	**27.45**

Q207a. Please provide detailed documentation of these claimed benefits.

A207a. To estimate the market impact of advanced diesel engine technologies in the heavy duty vehicle market, estimations of fuel and vehicle attributes were made for conventional and advanced technologies.[1] These estimations were put into the Heavy Duty Market Penetration Model to determine market acceptance and resulting market penetrations.[2] Market penetrations were put into the Integrated Market Penetration and Anticipated Cost of Transportation Technologies

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[1] For conventional vehicles: U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 1996, Washington, DC, January 1996, p. 92. For advanced technologies: Program goals as stated by the Office of Transportation Technologies.

[2] Maples, John D., and James S. Moore. DRAFT "Development Status of a Heavy Duty Truck Market Penetration Model." August 1995.

(IMPACTT) model.[1] The IMPACTT model calculates: new vehicle sales, vehicle stocks (including scrappage), vehicle utilization (miles traveled by vehicle by age of vehicle), alternative fuel use, oil displacement, and emissions reductions.

Using the Heavy Truck Market Penetration Model, it was estimated that advanced diesel engines would improve the operating efficiency of heavy trucks by 50% and would enter the market in 2000. The following table details the market penetration, stocks, alternative fuel use, gasoline displaced, energy cost savings and carbon reductions of these technologies.

Heavy Duty Vehicles	2000	2010	2020
Market Penetration	1.2%	100%	100%
Alternative Fuel Used (MBPD)*	0.00	0.00	0.00
Diesel Displaced (MBPD)	0.00	0.20	0.65
Energy Cost Savings (Billions of $)	0.05	4.19	13.66
Carbon Reductions (MMTons)	0.10	8.50	27.45

*Million Barrels per Day, equivalent to oil on a BTU basis.

Q207b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

The heavy duty engine estimated benefits would probably eventually be realized if DOE funding stopped, but at a much later date. As an approximate estimate of the delay, the year 2010 benefits estimated with the DOE funding might be delayed to the year 2020.

Q208. Please provide a listing of the recipients of (i) the $4,550,000 in funding in FY 1995, (ii) the $5,267,000 in FY 1996 funding, and (iii) the requested level of $10,100,000 in FY 1997 for Light Duty Engine R&D for each of PNGV: Advanced Automotive Piston Engine R&D and PNGV: Combustion Efficiency and Emissions R&D.

Q209. For each recipient of Light Duty Engine R&D funds identified in the response to question 208 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A208 and A209. The following table provides the information requested (In Thousands of $):

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	INEL	835	100	0	N
2	ANL	830	235	262	N
3	PNNL	1,142	805	1,080	N
4	ORNL	0	350	TBD	N
5	SNL	980	1,810	TBD	N
6	Princeton University	0	0	0	Y
7	Imperial College	0	0	0	Y
8	Florida A&M	0	0	0	Y
9	Massachusetts Inst. of Tech.	0	0	0	Y

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[1] Mintz, M.M., M.M. Tompkins, and J. Camp. "The IMPACTT Model: Structure and Technical Description," (ANLIESD/FM-93), Argonne National Laboratory, Argonne, IL, December 1994.

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
10	Pennsylvania State University	0	0	0	Y
11	University of Illinois	0	0	0	Y
12	Drexel University	0	0	0	Y
	Total	3,787	3,300	TBD	

Q210. For those Light Duty Engine R&D funding recipients identified in the response to question 209 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A210. See the answer to question 208. Laboratory (Nos. 1-5) funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q211. Please provide a listing of the recipients of (i) the $5,890,000 in funding in FY 1995, (ii) the $5,454,000 in FY 1996 funding, and (iii) the requested level of $7,100,000 in FY 1997 for Heavy Duty Engine R&D for each of In-Cylinder Efficiency/Emissions R&D and Emission Control and Aftertreatment R&D.

Q212. For each recipient of Heavy Duty Engine R&D funds identified in the response to question 212 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A211 and A212. The following table provides the information requested (In Thousands of $):

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
1	Hi-Z Technology, Inc.	10	10	100	Y
2	Cummins and Texaco	100	63	400	Y
3	University of Wisconsin	0	0	0	Y
4	Cummins Engine Company	0	50	50	N
5	Detroit Diesel Corp., AlliedSignal, and Delphi	138	183	225	Y
6	Cummins, Engelhard, Remaxco	138	213	225	Y
7	Caterpiller Inc.	0	38	125	Y
8	Caterpiller Inc.	125	129	745*	Y
9	Cummins Engine Co.	232	129		
10	Detroit Diesel Corporation	212	129		
11	University of Wisconsin-Madison	0	0	0	N
12	Detroit Diesel/Electrofuel	25	0	0	Y
13	University of Illinois-Urbana	0	0	0	N
14	Sandia National Laboratories	0	0	0	N
15	Oak Ridge National Laboratory	0	0	0	N
16	NASA Lewis Research Center	0	0	0	N
	Total	980	944	1,870	

*Competitive procurement in process on LE-55 prototype development

Q213. For those Heavy Duty Engine R&D funding recipients identified in the response to question 212 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A213. See the answers to questions 211 and 212. With regard to grants to the University of Wisconsin and the University of Illinois (Nos. 11 and 13), these universities posses a unique combination of facilities and resources which are not available any place else. They have the four key elements which are integral in forming the total research program: (1) the appropriate equipment to test engines; (2) laser diagnostic equipment and instrumentation to perform research on engines; (3) computational facilities on site to perform the modeling, analysis, and simulation associated with performing engine research; and (4) the involvement of major engine companies to provide modified engines, equipment and required personnel. Laboratory funding (Nos. 14 and 15) is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. The non-competitive award was made to NASA Lewis Research Center (No. 16), due to its unique capabilities in a variety of engine research areas. NASA has facilities for doing innovative work in the areas of foil bearings and thermal barrier coatings which cannot be performed elsewhere.

Transportation Sector Implementation and Deployment

Q214. On page 329 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The technology assessment activity estimates the impacts, benefits, and costs of new transportation vehicle and fuel technologies. A system of models has been created that: (1) estimates the market shares of new light duty vehicle sales for various vehicle technologies; (2) calculates the alternative fuel use, petroleum reductions, and ambient and global emissions; and (3) estimates the impacts on Gross Domestic Product and employment."

Please describe each of these models, including identification of the model developer(s), and peer-review process used to validate the models.

A214. The modeling methodology is described in detail in the attached document entitled "OTI Program Analysis Methodology." In summary, the benefits estimates require that the technologies being funded by DOE be characterized in terms of their initial dates of introduction, their incremental costs, their fuel efficiencies, the fuel they use, their range (if different from the conventional vehicle), and the changes in these characteristics over time. Exhibit 2 shows these assumptions, which assume full DOE funding and technical success of the research goals.

The vehicles with these characteristics are plugged into the vehicle choice model which is explained in detail in the 1994 Ph.D. dissertation by the model's author Lewis Fulton. In summary, this model used the best available data to calibrate the coefficients that determine the market share for alternative vehicle technologies.

DRAFT - FOR REVIEW AND COMMENT

OTT Program Analysis Methodology

U.S. DEPARTMENT OF ENERGY

Assistant Secretary for Energy Efficiency and Renewable Energy

Office of Transportation Technologies

February 28, 1996

DRAFT - FOR REVIEW AND COMMENT

OTT Program Analysis and Assessment
Methodology and Results:
STATUS REPORT

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1.0 INTRODUCTION

This is a status report on the analysis and assessment methodology employed by the Office of Transportation Technologies (OTT) used in support of the Office of Energy Efficiency and Renewable Energy's Quality Metrics Performance Measures and Strategic Principals initiative. It was prepared as part of a series of "living documents" that are periodically issued to describe the current status of the methodology development and results.

The methodology is applied to nine "Planning Units" which represent the principal program activities of the DOE-OTT:

Alternative Fuels and Vehicles

1. Biofuels
2. Alternative Fuel Vehicles (R & D and deployment)

Electric Vehicle Technologies

3. Electric Vehicle R&D
4. Hybrid Vehicle R&D
5. Fuel Cell R&D

Transportation Material Technologies

6. Ceramic Materials R&D
7. Lightweight Materials R&D

Combustion Engine R&D

8. Light Duty Engine R&D
9. Heavy Duty R&D

The basis for the development of this report results from a five-year transportation research and development plan was developed as required by Section 2021 of Public Law 102-486, the Energy Policy Act of 1992 (EPACT). The plan described an overall framework within which research and development (R&D) is conducted by the DOE Office of Transportation Technologies (Ref. 1). The plan also provided the basis for the results developed under the previous Quality Metrics analysis effort- QM 95.

The OTT R&D framework was defined as a result of an intensive analytical effort to assess societal benefits relative to Federal government budget expenditures that would occur throughout the estimated duration of a variety of R&D programs.

An overview of the technical analysis process is described in Section 2. Section 3 contains a description of the vehicle choice analysis simulation tool and results. Market penetration results for the current Quality Metrics (QM 97) are indicated for light-duty vehicle technologies, as well as comparisons to other market penetration scenarios. Section 4 summarizes the approach used to project overall energy and emissions impacts of the alternative vehicle technologies. Section 5 presents a brief description of the methodology for determining economic (gross domestic product-GDP) and employment effects of the R&D program strategies. The final discussion, Section 6, contains summary observations concerning the analysis process, and identifies technical subjects that merit refinement and/or additional analysis in the near future.

2.0 TECHNICAL ANALYSIS OVERVIEW

Technologies currently addressed in the analytical evaluations include the planning units listed in Section 1.0. The work completed to date has addressed benefits from the perspective of individual planning units. Efforts also are in progress on composite technology effects.

Analyses consider a time frame that spans 1995 through 2020. The end date was selected in order to enable accounting over the long time period needed for advanced vehicles to penetrate the overall vehicle fleet, and to consider the potential benefits of longer-term technologies such as fuel cells.

Strategy evaluations consist of a three-step process that addressed market penetration potentials, overall vehicle fleet transitions and the resulting energy and environmental benefits, and impacts on the economy as measured by gross domestic product (GDP) and employment growth. Analyses also emphasize light duty vehicles (LDVs), especially in personal use applications.

2.1 TECHNICAL CHARACTERISTICS

A range of technical and R&D Program characteristics were defined quantitatively for use in the analysis process. Particularly important characteristics included:

- **Year of expected commercial introduction of a technology** - For end-use vehicle technologies, this was defined as achieving commercial production of more than 20,000 vehicles per year.
- **Year of zero Government funding** - this time period is defined as the time at which R&D support would end, an indication that commercial introduction is imminent,
- **Relative cost of advanced technology** vehicle and alternative fuel compared to conventional vehicles and RFG,
- **Range between fuel refills** - also defined relative to ICE vehicles,
- **Emissions levels** of criteria pollutants,
- **Type of fuel**, and
- **Fuel Price.**

Characteristics were estimated based on the assumption that DOE program budget levels would be adequate to assure technological success at a ninety percent (90%) probability level.

The methodology provides for determining these characteristics through a series of meetings with DOE OTT program staff. Program panels address the following technology areas:

- Alternative Fuels Utilization
- Biomass-based fuels
- Electric Vehicles
- Fuel Cell Vehicles
- Hybrid-electric Vehicles
- Materials.

Where possible, two meetings are conducted. The purpose of the follow-up meeting is to review the initial parameters, and discuss any changes that seemed appropriate. Overall performance parameters were summarized and presented for review by the OTT Management. The results of this analysis are indicated in Exhibit 1.

EXHIBIT 1:

TECHNOLOGY CHARACTERISTICS/INPUTS FOR OTT TECHNOLOGY BENEFITS ANALYSIS - QUALITY METRICS 1997

TECHNOLOGY	YEAR OF INTRO./ ZERO GOVT. FUNDING	VEHICLE COST RATIO	FUEL ECONOMY RATIO	RELATIVE RANGE	EMISSIONS (TAIL PIPE)	TYPE OF FUEL	FUEL PRICE. $/GAL. (Equiv.)	COMMENTS
VEHICLE TECHNOLOGIES								
ELECTRIC	1998	1.6	3.3	0.33	0	NON-	1.79	
	2003	1.1	5.3	0.67		PETRO.	1.81	
ADV. DIESEL	2002	1.1	1.25	1	TIER II	D.F. NO. 2	$1.28	
	2005	1.02	1.35	1		D.F. NO. 2	$1.25	
HYBRID 1	2002	1.2	1.7	1	TIER 0	GASOLINE	1.34	Also can use other liquid or gaseous state fuels.
	2005	1.02	2.1	1			1.35	
HYBRID 2	2006	1.2	2.5	1	TIER 0	GASOLINE	1.28	Also can use other liquid or gaseous state fuels.
(PNGV)	2015	1.07	3	1			1.42	
FUEL CELL	2007	1.45	2.1	1	ULEV	METHANOL/	1.27	Also can use hydrogen.
	2012	1.1	3	1		ETHANOL	1.25	
COMPRESSED	1995	1.2	1	0.7	TIER 0	NATURAL	0.69	
NATURAL GAS	2003	1.08	1	0.9		GAS	0.95	
LPG	1995	1.015	1.015	1	TIER E	PROPANE	1.07	
	2003	1.013	1.013	1			1.17	
ETHANOL-	2005	1	1.15	0.9	TIER 0	ETHANOL	1.27	
FUELED	2010	1	1.15	0.9			1.25	
LIGHT WEIGHT	2002	1.07	1.21	1	TIER 0	GASOLINE	1.34	
(ALUMINUM)	2010	1.03	1.21	1			1.4	

NOTE 1: Mature" is defined as the time of "zero Government funding".

External peer reviews comprise an important part of the analysis methodology. External peer reviews are being performed for the current Quality Metrics 97 efforts by the Energy Information Administration, Arthur D. Little, Inc., and Applied Energy Systems, Inc.

Previous assumptions and analyses completed for QM 95 were subjected to independent review. As a part of this process, of sixteen (16) persons from the automotive industry, fuels industry, state and local government, professional organizations, and independent Federal government and research organizations reviewed vehicle attribute assumptions. The revised technical characteristics that resulted from these reviews are indicated in Exhibit 2.

EXHIBIT 2:

OTT TECHNOLOGY CHARACTERISTICS - QUALITY METRICS 95 (EPACT R&D PLAN)

TECHNOLOGY	YEAR OF INTRO.	YEAR OF MATURITY	VEHICLE COST RATIO	FUEL ECONOMY RATIO	RELATIVE RANGE	EMIS-SIONS	TYPE OF FUEL
VEHICLE TECHNOLOGIES							
ELECTRIC VEHICLE	1997	2005	INITIAL: 1.6 MATURE: 1.1	INITIAL: 2.35 MATURE: 3.72	INITIAL: 0.25 MATURE: 0.5	0	NON-PETRO.
HYBRID VEHICLE	2003	2008	INITIAL: 1.3 MATURE: 1.1	INITIAL: 1.42 MATURE: 2.4	INITIAL: 1.0 MATURE: 1.0	TIER II	ANY
FUEL CELL VEHICLE	2007	2017	INITIAL: 1.4 MATURE: 1.1	INITIAL: 1.92 MATURE: 3.18	INITIAL: 1.0 MATURE: 1.0	ULEV	ANY
ALT. FUEL VEHICLE	1997	2003	INITIAL: 1.05 MATURE: 1.0	INITIAL: 1.0 MATURE: 1.0	INITIAL: 0.7 MATURE: 0.9	TIER II	NATURAL GAS
SUPPLY/CROSS-CUTTING TECHNOLS.							
BIO-FUELS PRODUCTION	2005	2010	INITIAL: 1.0 MATURE: 0.9	N/A	N/A	N/A	ETHANOL AND METHANOL
VEHICLE MATERIALS	2000	2015	INITIAL: 1.2 MATURE: 1.0	N/A	N/A	N/A	N/A

2.2 · COST ANALYSIS

As a result of previous methodology development and application work in 1994, the importance of consistent and comprehensive cost analysis is apparent. Current efforts have included an analysis of life-cycle costs to provide feedback on the implications of the attributes and to assess whether or not the attribute characteristics appear viable from the perspective of life-cycle cost.

Analysis Approach:

The life cycle costing method includes allowances for all cost elements likely to occur during the life of a vehicle. Categories that have been defined include the following:

- Purchase cost,
- Energy/fuel cost, and
- Other operating and maintenance costs, which include a variety of elements: maintenance and repair, tire replacement, local registration fees, and insurance.

The contributing cost elements were utilized to determine two measures of relative cost-effectiveness:

- **Net present worth** (also called total present cost or net present cost)- which involves the accumulation of all costs - both capital and operating into a single value. Annual operating costs such as energy are represented as a single value through a discount factor which is unique to the assumed lifetime and discount rate.
- **Incremental payback-** which indicates the time that it takes for an incremental initial cost-- in this case the purchase cost differences of an advanced technology vehicle compared to a conventional vehicle-- to be offset by operating cost reductions; e.g. lower energy cost due to higher fuel economy.

Analyses were performed for 3 cases: year 2000, year 2010, and the years in which each technology is projected to reach maturity.

The technology characteristics indicated in Exhibit 1 were used as the basis for generating a set of projections for each technology to the year 2015. The characteristics and cost elements were used to generate energy cost estimates for each technology. In addition to estimating the annual energy cost, cost reductions also are indicated. By the year 2010 each advanced technology will result in substantial energy cost reductions compared to the baseline ICE gasoline vehicle.

The dollar value of the relative capital cost differences also was determined. Capital cost estimates reflect "1990 dollars".

Discussion of Results:

The net present cost comparisons for one set of analysis projections representing the year 2010 are indicated in Exhibit 3. Exhibit entries show that several advanced technologies will have lower life cycle cost than ICEs by 2010. These include: hybrid technologies and ethanol-fueled vehicles. These technologies also show favorable payback periods, or no payback period- which is a result of the fact that no purchase cost difference compared to ICE is anticipated. Other technologies also will be competitive on a life-cycle cost basis.

EXHIBIT 3:

VEHICLE TECHNOLOGY NET PRESENT COST SUMMARY COMPARISON

YEAR 2010

TECHNOLOGY	TIME FRAME	VEHICLE PURCHASE COST, $	ENERGY COST		OTHER O&M AND FIXED COSTS		TOTAL PRESENT COST, $	PAYBACK PERIOD, YRS.	RANK
			ANNUAL, $	PRESENT WORTH, $	ANNUAL, $	PRESENT WORTH, $			
GASOLINE ICE	2010	22,300	446	3,770	1,450	12,256	38,325	N/A	6
ADV. DIESEL	2010	22,701	$311	2,633	1,450	12,266	37,590	3	4
ELECTRIC	2010	24,530	$197	1,662	1,450	12,256	38,448	9	8
HYBRID 1	2010	22,701	$164	1,366	1,450	12,256	36,343	2	1
HYBRID 2	2010	23,661	$164	1,386	1,450	12,256	37,503	6	3
FUEL CELL	2010	27,206	$161	1,276	1,450	12,266	40,737	17	10
COMPRESSED NATURAL GAS	2010	23,416	$344	2,908	1,450	12,256	38,579	11	9
LPG	2010	22,300	$386	3,268	1,450	12,256	37,814	0	5
ETHANOL-FUELED	2010	22,300	$346	2,927	1,450	12,256	37,483	0	2
LIGHT WEIGHT (ALUMINUM)	2010	22,969	$368	3,116	1,450	12,256	38,340	0	7

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- PRELIMINARY -

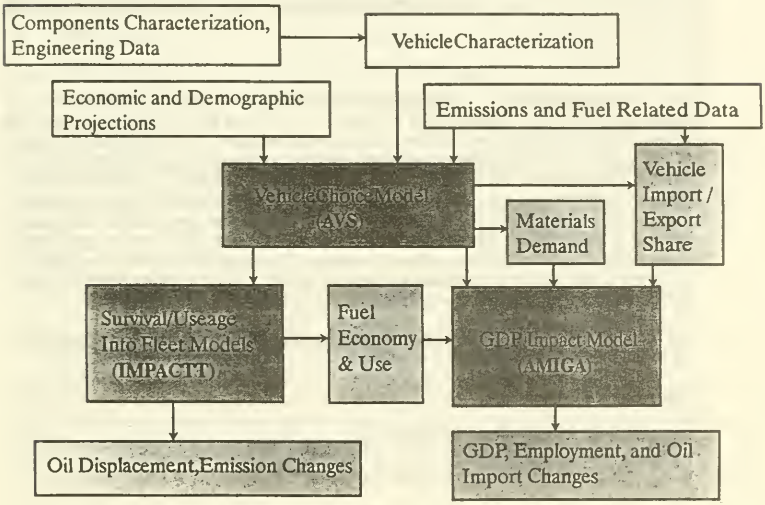
Two important caveats concerning these results are offered for consideration. The electric vehicle costs assume no cost for battery replacement. However, electrical energy costs were based on average residential costs, which may be higher than available in many recharging situations. In addition, we have held other operations and maintenance costs constant to those assumed for conventional ICE vehicles. This cost category contains many elements including: repairs, tire replacements, taxes, licensing fees, and insurance; some of which are typically correlated to vehicle purchase cost.

2.3 ANALYSIS TOOLS

Three computer analysis models were used to quantify the benefits of advanced vehicle technologies. The three models are: Alternative Vehicle Sales (AVS), for determining market penetrations, Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT), for determining energy and environmental effects, and the Argonne Multi-sector Industry Growth Assessment (AMIGA) model, for evaluating gross domestic product and employment changes. The relationships of these three models as applied to the OTT planning process are indicated in Exhibit 4. Emissions analyses have been supplemented through the use of the Greenhouse Gas Emissions model developed by Argonne National Laboratory. Excerpts of model documentation are presented in the Appendix.

EXHIBIT 4:

ANALYTICAL MODELS USED IN THE OTT PLANNING PROCESS


Components Characterization, Engineering Data
VehicleCharacterization
Economic and Demographic Projections
Emissions and Fuel Related Data
VehicleChoice Model (AVS)
Vehicle Import / Export Share
Materials Demand
Survival/Useage Into Fleet Models (IMPACTT)
Fuel Economy & Use
GDP Impact Model (AMIGA)
Oil Displacement,Emission Changes
GDP, Employment, and Oil Import Changes

3.0 VEHICLE CHOICE ANALYSIS

Market penetration estimates generated for EPACT 2021 relied on the use of the Alternative Vehicle Sales (AVS) model version 1.3. This model is a discrete choice, multinomial logit model designed to simulate the household market for alternative-fuel light-duty vehicles. The model forecasts, to the year 2020, the future sales of alternatively fueled light-duty vehicles by technology and fuel type. These estimates are based on consumer derived utilities related to a set of vehicle attributes that are associated with each of the different technologies.

The vehicle demand function used in this model is based on a utility-maximization theory which defines the consumer demand for alternative vehicles as a function of the attributes of these vehicles and the fuels they use. The total utility of each light-duty vehicle technology and fuel is determined by the sum of the attribute utilities of that vehicle. The market share penetration estimates for the different technologies are a function of each technology's total utility compared to the total utility of other vehicles and technologies in the market. The technology's total utility is calculated by summing attribute input values that have been determined by multiplying the attribute by its corresponding utility value.

3.1 AVS 1.3

AVS 1.3 estimates the market share penetration of alternative-fuel light-duty vehicles for twelve individual technologies, which are listed in Exhibit 5. The twelve vehicle technologies contained within the model can be described as follows: conventional vehicles with internal combustion engines (ICEs) operating on either gasoline; conventional vehicles with ICEs operating on diesel; contentional vehicles with advanced diesel engines, light weight aluminum intensive conventional vehicles; conventional vehicles with flex-fuel capability operating on a variable mixture of gasoline and alcohol fuels (ethanol or methanol); ICE dedicated alternative fuel vehicles operating on either alcohol (ethanol or methanol) or gaseous fuels (compressed natural gas or liquid propane gas); electric vehicles, hybrid electric vehicles with gas turbine engines and electric motors operating on compressed natural gas and electricity; and fuel cell vehicles with on-board methanol reformers. Only technologies for which there are OTT programs are included in this analysis.

For each technology, the model considers a set of generic vehicle attributes representative of all vehicles within that technology and a set of fuel attributes corresponding to that technology.

The vehicle attributes include:

1) Vehicle purchase price in 1990 dollars,

2) Vehicle efficiency in equivalent miles per gallon of gasoline,

3) Tailpipe emissions, and

4) Range, defined as miles traveled before refueling is required.

The fuel attributes include:

1) The fuel price estimated in dollars per gallon of gasoline equivalent, and

2) The availability of the fuel.

EXHIBIT 5: AVS 1.3 VEHICLE TECHNOLOGY DESCRIPTIONS

Vehicle Technology Characteristics		
Technology	**Propulsion System**	**Fuel Type**
Conventional	ICE	Gasoline
Conventional	ICE	Diesel
Flex Fuel Alcohol	ICE	Gasoline\Ethanol
Dedicated Alcohol	ICE	95% Ethanol
Flex Fuel Alcohol	ICE	Gasoline\Methanol
Dedicated Alcohol	ICE	85% Methanol
Electric	Electric Motor	Electricity
Hybrid Electric I	ICE\Electric Motor	Any\Electricity
Hybrid Electric II	Gas Turbine\Electric Motor	Any
Dedicated CNG	ICE	Compressed Natural Gas
Dedicated LPG	ICE	Liquid Propane Gas
Fuel Cell	Electric Motor	Methanol

Consumer derived utilities for attributes described in the AVS model were estimated from data collected in a 1991 stated preference survey conducted by Bunch, et al, in the South Coast Air Basin of California (Ref. 3). The attribute coefficients were derived from analyses using a discrete choice multinomial logit model. In their analyses, Bunch, et al, estimated attribute coefficients and constant terms for four technology types: 1) dedicated alternative fuel vehicles, 2) multiple fuel vehicles, 3) electric vehicles, and 4) hybrid electric vehicles. In order relate the results of the research by Bunch, et al, to the twelve technologies evaluated in the OTT planning process, several simplifying assumptions and judgement-based extrapolations were made.

It is important to note that a major limitation in estimating the potential household market penetration of alternative vehicle technologies is the lack of *revealed preference data*. Revealed preference data is gathered from actual consumer response in the market place. Currently, there are only a limited number of alternative-fuel technologies commercially available. Although purchase and use data are being collected on these vehicles, they are primarily owned by fleet operators, reflecting the desired attribute utilities of that market.

3.2 AVS 8.1

As the analytical process has evolved, the methodology has incorporated the use of AVS version 8.1. The basic structure of AVS 8.1 still relies on the calculation of market share based on a discrete choice, multinomial logit model simulating the household market for alternatively fueled light-duty vehicles. But, additions to AVS 8.1 include demographic characteristics used to segment the market, feed back loops that determine vehicle availability and fuel availability, and the inclusion of greenhouse gas tailpipe emissions as a vehicle attribute.

In AVS 8.1, demographic characteristics are segmented in two different manners: by income, education, and geographic area; or by number of vehicles per household (0-1, 2, and 3 or more), education, and geographic area. In this analysis, market penetration estimates are determined by income, education, and geographic area. These characteristics are defined as follows:

- Income: less than $35,000 per year or greater than $35,000 per year,
- Education: college degree or no college degree, and
- Geographic: Clean Air Act attainment area, or Clean Air Act non-attainment area.

The model is designed to estimate vehicle market shares for each of the eight classes using the relevant consumer preference coefficients and vehicle and fuel attributes for each individual class. In terms of consumer preference, the difference in educational class is the most important factor because separate choice models were estimated for each of these two groups; the income classes are important in terms of gasoline vehicle preference due to the alternative fuel constant for high income; and differences in preferences due to geography reflect the value placed on reduced emissions; households outside non-attainment zones are assumed to place half as much importance on local-area emissions.

Aggregate market penetration is estimated as a weighted average of the eight individual class shares. Exhibit 6 below details the population distribution by class for the weighted calculation. It is assumed that this distribution remains constant over time.

EXHIBIT 6: POPULATION DISTRIBUTION BY CLASS

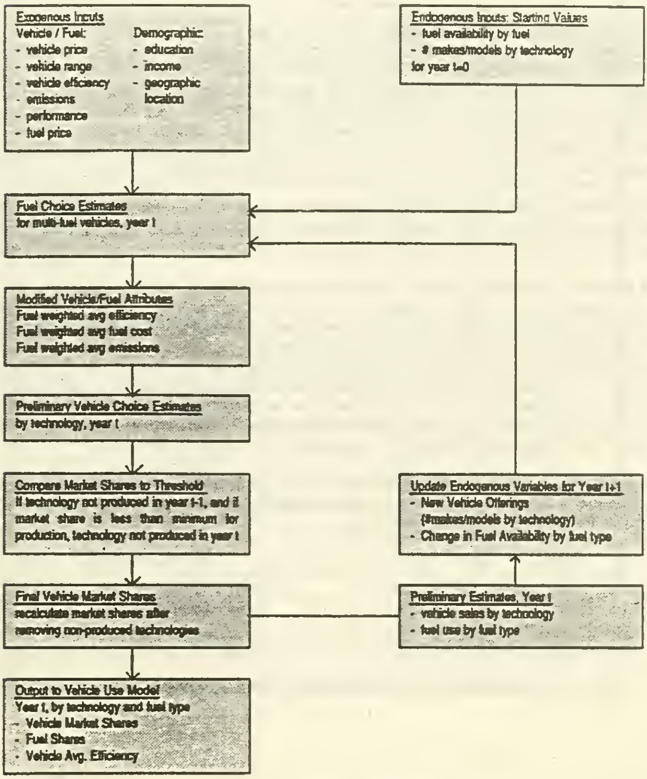
	Non-attainment	Attainment	Total
High education, High income	13%	6%	19%
High education, Low income	7%	3%	10%
Low education, High Income	18%	9%	27%
Low education, Low income	29%	15%	44%
Total	67%	33%	100%

AVS 8.1 also includes two vehicle/fuel attributes that are calculated endogenously, vehicle availability and fuel availability. These are also the new supply-side components that have been added to the model. Vehicle availability is defined as the number of individual make/models offered for sale within that class. This is determined in each forecast year by the demand for that class in the previous year. It is assumed that manufactures enter the AFV market if the demand for that technology, divided by the current number of make/model offerings, exceeds a given threshold (20,000 vehicles per year). This approach to estimating the number of vehicle model offerings results in the number of models tracking the demand for vehicles. As a result, when demand increases, the number of makes and models increases which in turn increases demand.

A similar dynamic is used to calculate fuel availability. As vehicles that are capable of using a particular fuel are purchased, potential fuel demand grows. Fuel suppliers are assumed to enter the market when the potential demand achieves a threshold level. In each forecast year the potential demand for each fuel is estimated, and checked against available supply (constrained by retail refueling capacity). If fuel demand is constrained by retail supply capacity, then in the following year, additional refueling stations open such that the new number of stations become sufficient based on last years demand. As a result, when stations increase so does fuel availability which in turn increases vehicle demand, which increases fuel demand. Exhibit 7 shows a flow chart illustrating the dynamic structure of AVS 8.1.

EXHIBIT 7:

VEHICLE MARKET MODEL STRUCTURE


Exogenous Inputs
Vehicle / Fuel:
- vehicle price
- vehicle range
- vehicle efficiency
- emissions
- performance
- fuel price
Demographic:
- education
- income
- geographic location
Endogenous Inputs: Starting Values
- fuel availability by fuel
- # makes/models by technology
for year t=0
Fuel Choice Estimates
for multi-fuel vehicles, year t
Modified Vehicle/Fuel Attributes
Fuel weighted avg efficiency
Fuel weighted avg fuel cost
Fuel weighted avg emissions
Preliminary Vehicle Choice Estimates
by technology, year t
Compare Market Shares to Threshold
If technology not produced in year t-1, and if market share is less than minimum for production, technology not produced in year t
Final Vehicle Market Shares
recalculate market shares after removing non-produced technologies
Output to Vehicle Use Model
Year t, by technology and fuel type
- Vehicle Market Shares
- Fuel Shares
- Vehicle Avg. Efficiency
Update Endogenous Variables for Year t+1
- New Vehicle Offerings (#makes/models by technology)
- Change in Fuel Availability by fuel type
Preliminary Estimates, Year t
- vehicle sales by technology
- fuel use by fuel type

The output of the AVS simulations are estimated market shares of new car sales (in percentages) of the alternative vehicle technologies, and the conventional vehicle technologies. The results are applicable to consumer, personal use vehicle purchase decisions.

Exhibit 8 is a representative output comparing estimated market penetrations generated for QM 95 using AVS 1.3 and market penetrations generated for QM 97 using AVS 8.1. The QM 95 market penetration estimates assume the vehicle attribute values shown in Exhibit 2. Market penetration estimates generated for Quality Metrics 97 are based on vehicle attribute values illustrated in Exhibit 1.

The market penetration estimates generated through the use of the AVS models has been analyzed in comparison to other recent market research activities. The results of one assessment are indicated in Exhibit 9. This exhibit indicates four market penetration scenarios: Quality Metrics 95, the mean estimates from a recently completed Delphi survey, the optimistic estimates from a recent completed Delphi survey, and Quality Metrics 97 (Ref. 4). The bar chart shows two clusters of penetration estimates: year 2010 (left side of chart), and year 2020 (right side of chart). Each bar is made up of market penetration estimates for three technologies: hybrid, electric, and fuel cell; though fuel cells are projected to not be penetrating the marketplace in the year 2010.

It can be seen that the AVS-generated penetration estimates are more optimistic than the Delphi respondents for the year 2010. However, the optimistic Delphi respondants provided the greatest estimate of market penetration for the year 2020.

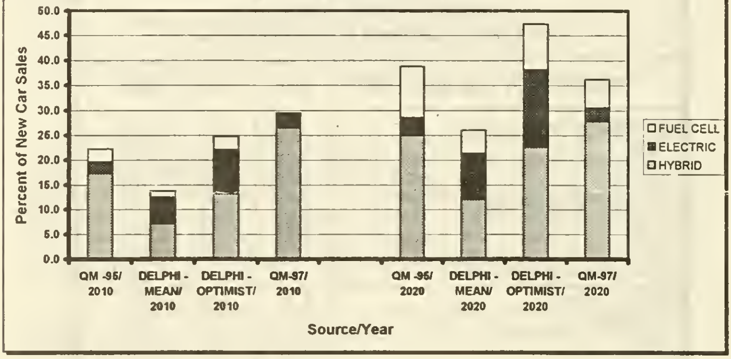
The market penetrations indicated in Exhibit 9 are aggressive, and reflect assumptions concerning funding levels, and funding level consistency which may or may not be realized. However, it is interesting to compare these estimates to other historical examples of fuel switching that have occurred in the U.S. A recent analysis contained in Reference 5, cites six examples spanning the shift from wood to coal in railroads, to the transition from leaded to unleaded gasoline in light-duty vehicles. A substantial part of these transitions were shown to have occurred during fifteen year periods. In some cases the fifteen years elapsed after an initial market penetration threshold had occurred (e.g. coal to oil in ground transportation and gasoline to diesel in public transportation); and in others the growth occurred after initial market entry (e.g. coal to diesel railroads).

In view of the preceding, it is observed that the AVS results have provided market penetration estimates that are generally consistent with other recent forecasts, and that they are consistent with historical fuel switching precedents and patterns.

EXHIBIT 8:
Market Penetration Comparison QM 97 and QM 95 Alternative Vehicle Technologies,
(All Values are Percent of New Vehicle Sales)

TECHNOLOGY - QM ANALYSIS	2000	2010	2020
AFV DEMONSTRATION - QM 95	3.6%	9.7%	13.2%
CNG	1.4%	5.5%	7.4%
LPG	2.2%	4.2%	5.8%
ALT. FUEL VEHICLES - QM 97	4.9%	1.1%	1.0%
CNG	2.1%	0.5%	0.5%
LPG	2.8%	0.6%	0.5%
QM 97 - QM 95 DIFFERENCE	1.3%	-8.6%	-12.2%
BIOFUELS - QM 95	6.1%	15.1%	24.1%
DEDICATED	0.0%	3.2%	7.1%
FLEX	6.1%	11.9%	17.0%
BIOFUELS - QM 97	6.6%	20.7%	19.7%
DEDICATED	NA	NA	NA
FLEX	6.6%	20.7%	19.7%
QM 97 - QM 95 DIFFERENCE	0.5%	5.6%	-4.4%
ELECTRIC VEHICLE R&D - QM 95	0.4%	2.3%	3.6%
ELECTRIC VEHICLE R&D - QM 97	3.3%	3.0%	2.7%
QM 97 - QM 95 DIFFERENCE	2.9%	0.7%	-0.9%
HYBRID VEHICLE R&D - QM 95	0.0%	17.3%	24.9%
HYBRID VEHICLE R&D - QM 97	0.0%	26.5%	27.8%
QM 97 - QM 95 DIFFERENCE	0.0%	9.2%	2.9%
FUEL CELL VEHICLE R&D - QM 95	0.0%	2.6%	10.3%
FUEL CELL VEHICLE R&D - QM 97	0.0%	0.0%	5.7%
QM 97 - QM 95 DIFFERENCE	0.0%	-2.6%	-4.6%
MATERIALS DEVELOPMENT - QM 95	1.0%	100.0%	100.0%
LIGHTWEIGHT MATERIALS - QM 97	0.0%	12.6%	11.2%
QM 97 - QM 95 DIFFERENCE	-1.0%	-87.4%	-88.8%
ADVANCED DIESEL - QM 97 (ONLY)	0.0%	10.0%	8.4%

EXHIBIT 9:
Market Penetration Comparisons



4.0 ENERGY AND ENVIRONMENTAL BENEFITS ANALYSIS

Once estimates for new car market shares were available, it was possible to develop estimates of overall energy, petroleum use, and environmental (criteria pollutant) emissions changes for the period spanning 1995 through 2020.

The Integrated Market Penetration and Anticipated Cost of Transportation Technologies (IMPACTT) model was used to estimate the oil displacement and emissions reduction potentials of each of the advanced technologies evaluated. Developed by Argonne National Laboratory's Center for Transportation Research, IMPACTT is a spreadsheet model operating in either Apple or DOS-compatible environments. The model calculates the effect of alternative vehicle characteristics and market penetration assumptions on baseline fuel use and emissions, and generated summary estimates of the value of oil displaced, emissions reduced, and total marginal capital costs borne by vehicle purchasers. Estimates are based on exogenous projections of conventional vehicle sales, market sales, and the characteristics of new conventional, and advanced technology vehicles.

Vehicle characteristics include fuel efficiency, emissions of nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and sulfur oxides (SOx), and incremental capital cost (i.e., the difference between the advanced technology vehicle cost and conventional vehicle cost). Petroleum displacement and emissions reductions are calculated as a function of the projected miles traveled, and the difference between the petroleum use and emissions of conventional vehicles and comparable projections for advanced technology vehicles that are projected to replace those vehicles.

4.1 METHODOLOGY

IMPACTT conceptually consists of several modules, the largest of which is the vehicle stock and usage module. Each spreadsheet contains "slots" for up to four copies of the IMPACTT model corresponding to independent combinations of vehicle class and technology alternative. Vehicle stock and emission results from each of the slots are summarized and summed at the top of the spreadsheet.

Each technology "slot" is modeled using a common approach. First, the vehicle stock and miles traveled by the advanced technology vehicles are determined, then this information is combined with efficiency estimates to develop fuel use and oil displacement. Fuel use changes are relative to consumption by conventional technology vehicles. The final step of the analysis calculates the emissions reduction associated with the advanced technology.

The vehicle stock and usage module is based on a capital vintaging model developed by Greene and Rathi (Ref. 6). The module calculates vehicle stock, annual miles traveled, and fuel displaced. New vehicle sales, market penetration rates, and scrap value are the key determinants of vehicle stock in each forecast year. Vehicle stock by vintage and an age-dependent utilization rate are the major determinants of vehicle use. Fuel displacement is then computed based on the sum of the projection of vehicle use and conventional vs. alternative vehicle fuel economy for each vintage. Exhibit 9 displays the variables used to project light-duty vehicle stock and usage. Comparable stock and usage projections for heavy-duty vehicles are produced within the model by applying historical survival and usage rates.

EXHIBIT 10:

VEHICLE STOCK AND USAGE MODULE

Characteristic	Variable	Description
Indices	i	Year index: 1990 to 2030
	j	Age index: 0 to 25 (heavy trucks); 0 to 17 (other)
Survival Model	A_0	Asymptotic survival rate parameter
	A_1	New car price depreciation parameter
	SDRATE	Scrap depreciation rate
	Sj	Survival age j
	MCij	Marginal vehicle technology cost, year i, age j
	SVij	Survival value, year i, age j
Sales i		Vehicle sales, year i
Vij		Number of new technology vehicles, year i, age j
SFj		Survival function indexed by age
Usage Model	Mj	Miles per year by age of vehicle
	UDRATE	Usage depreciation rate
	VMT ij	vehicle miles travelled per year i, age j

Energy and emissions effects of four vehicle classes can be evaluated by the IMPACTT model: automobiles, light-duty trucks, medium-duty trucks, and heavy-duty trucks. While specific assumptions vary by vehicle class and technology, a standardized framework has been developed for evaluating each of the technologies considered in the OTT Program Plan. This approach is described below.

The effect of energy use includes estimates of the quantity of gasoline (or diesel fuel) displaced by the use of an alternative-fueled vehicle and the quantity of alternative fuel consumed (e.g. KWH used by electric vehicles). Shown in Exhibit 10 are the key variables used in performing the energy impact analysis.

Gasoline displacement is calculated from age-specific VMT and on-road miles per gallon for that age vehicle. Technology specific parameters such as gasoline-equivalent MPG, and conversion efficiency values are used, as appropriate, to compute alternative fuel consumption.

EXHIBIT 11:
ENERGY USE MODULE

Variable	Description
MPGi	Miles per gallon for new vehicles, year i
GDi	Gasoline displaced, year i
GEMPG	Gasoline-equivalent MPG
BRATE	Technology-specific heat rate
ERATE	Technology-specific energy efficiency value

The last component of the IMPACTT model estimates the reduction in NOx, SOx, CO, and HC emissions associated with advanced-technology vehicles. Emission rates (in grams per mile) are modeled as a function of vehicle age for light-duty vehicles, thereby accounting for emissions deterioration as vehicles age. Constant emission rates are assumed for vehicles aged five (5) years and under. Emission rates are increased by a uniform rate for each of the years between six (6) years and ten (10) years of age. Emissions generation rates are assumed to remain constant after age ten. Emission reduction rates per mile by age of vehicle are obtained by determining the difference between the advanced and conventional technologies. The difference values are multiplied by vehicle miles traveled and converted to short tons.

In addition to short tons, the dollar value of the emissions reductions are reported. Unit dollar values are those recommended by the EPA (Ref. 7), except in the case of electric vehicles. Based on current plans of various states, it is assumed that electrics are only introduced in metropolitan areas with significant air quality problems. Consequently, the value of emissions reduced by electric vehicles is estimated to be higher. The summary results of the IMPACTT run for the Current Diversified OTT Program scenario are presented in the Appendix.

4.2 ENERGY IMPACTS

Energy use reductions due to OTT-supported advanced light duty vehicle transportation technologies are summarized in Exhibit 12 below. Consistent with the requirements of Quality Metrics, both primary energy displaced and primary oil displacement are shown in the table. It can be seen that the total oil displacement that will occur in the year 2020 is 3.2 mmb/d.

4.3 EMISSIONS BENEFITS

Projected emissions reductions for 2010 and 2020 are indicated in Exhibit 13. Reductions for NOx, Carbon Monoxide (CO), and Hydrocarbons were estimated through the use of the Greenhouse Gases, Regulated Emissions and Energy Use Model.

EXHIBIT 12:

ENERGY DISPLACEMENT RESULTS

Planning Unit	Primary Energy Displaced (mmb/d)			Primary Oil Displaced (mmb/d)		
	2000	2010	2020	2000	2010	2020
Alternative Fuel Vehicle R&D	0.00	0.00	0.00	0.06	0.13	0.07
Biofuels	0.01	0.30	0.70	0.01	0.30	0.70
Electric Vehicle R&D	0.03	0.11	0.09	0.01	0.15	0.12
Fuel Cell R&D	0.00	0.00	0.19	0.00	0.00	0.19
Heavy Duty R&D	0.00	0.20	0.65	0.00	0.20	0.65
Hybrid Vehicle R&D	0.00	0.47	0.87	0.00	0.77	1.21
Light Duty Engine R&D	0.00	0.13	0.14	0.00	0.13	0.14
Lightweight Vehicle Materials	0.00	0.11	0.12	0.00	0.11	0.12
Propulsion Systems Materials	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	1.32	2.76	0.09	1.78	3.20

Source: Quality Metrics Analysis (John Maples, University of Tennessee, February 1996)

EXHIBIT 13:

EMISSIONS REDUCTIONS ESTIMATES

PLANNING UNIT	YEAR 2010 (1000 TONNES)			YEAR 2020 (1000 TONNES)		
	NOx	CO	HC	NOx	CO	HC
ALT. FUEL VEHICLE R&D	4.7	360.2	52.0	1.9	124.0	17.4
BIOFUELS	-30.7	162.6	36.3	-73.1	405.5	110.8
ELECTRIC VEHICLE R&D	62.5	924.7	77.3	45.1	640.4	64.9
FUEL CELL R&D	0.0	0.0	0.0	28.8	494.3	45.5
HYBRID VEHICLE R&D	176.0	2,021.7	187.2	276.9	3,077.8	327.3
LIGHT DUTY ENGINE R&D	-63.3	1,378.3	92.3	-112.6	1,920.3	135.8
LIGHTWEIGHT MATERIALS R&D	9.7	2.2	3.1	10.9	10.9	3.5
PROPULSION SYSTEM MATLS.	0.0	0.0	0.0	0.0	0.0	0.0
HEAVY DUTY R&D	96.9	NA	NA	318.8	NA	NA
TOTAL	255.8	4,849.7	448.2	496.7	8,673.2	705.0

Source: Quality Metrics Analysis (John Maples, University of Tennessee, February 1996)

4.4 CARBON DIOXIDE BENEFITS ANALYSIS

The OTT Program Analysis and Assessment Methodology includes estimating reductions in carbon emissions from the commercial utilization of OTT-sponsored technologies. Currently, the structure of the EE Quality Metrics Performance Measures and Strategic Principals activity results in benefits impacts being quantified by non-OTT parties Estimated carbon emissions reductions are indicated in Exhibit 14..

EXHIBIT 14:

CARBON REDUCTION ESTIMATES

	Carbon Reductions (MMTons)		
Planning Unit	2000	2010	2020
Alternative Fuel Vehicle R&D	1.01	2.08	1.11
Biofuels	0.39	10.61	29.30
Electric Vehicle R&D	0.00	1.46	1.83
Fuel Cell R&D	0.00	0.00	8.09
Heavy Duty R&D	0.00	8.17	26.22
Hybrid Vehicle R&D	0.00	-5.37	9.19
Light Duty Engine R&D	0.00	2.42	5.71
Lightweight Vehicle Materials R&D	0.00	2.27	4.91
Propulsion System Materials	0.00	0.00	0.00
Total	1.40	21.64	86.36

Source: Quality Metrics Analysis (Compiled by John Maples, U.T., February 1996)

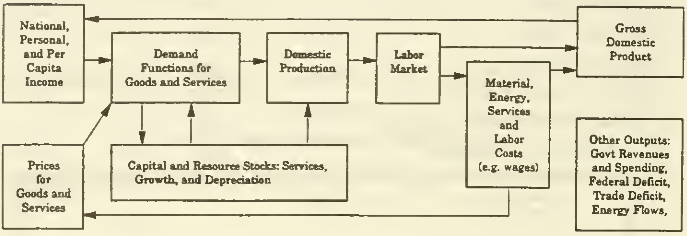
5.0 ECONOMIC IMPACT ANALYSIS

5.1 METHODOLOGY

A block diagram of the AMIGA model is shown in Exhibit 15. Final demands for goods and services are functions of income, relative prices, and other variables. AMIGA is a simultaneous equation model because the income and price variables used as inputs to the demand functions are also calculated as outputs of the model. Other outputs of the model are sectoral production levels and employment by sector. Costs and price markups are also calculated by sector. Technical coefficients, i.e., the amount of material or service i used to produce sector output k, are used both to calculate the intermediate demand for sector output and to calculate the real costs of sector output.

EXHIBIT 15:
DIAGRAM OF "AMIGA" MODEL

The AMIGA* Model represents the economy as a nonlinear, simultaneously interrelated system


National, Personal, and Per Capita Income
Demand Functions for Goods and Services
Domestic Production
Labor Market
Gross Domestic Product
Material, Energy, Services and Labor Costs (e.g. wages)
Prices for Goods and Services
Capital and Resource Stocks: Services, Growth, and Depreciation
Other Outputs: Govt Revenues and Spending, Federal Deficit, Trade Deficit, Energy Flows,

*** Argonne Multisector Industry Growth Assessment Model**

In this application, the AMIGA model utilized the technical coefficients of a few "generic" advanced vehicle types. However, any number of advanced technology sectors can be appended to the AMIGA model. Marc Ross, of the University of Michigan, has developed a motor vehicle manufacturing module for AMIGA which has the technical coefficients for advanced motor vehicles. These technical coefficients are used to forecast the sectoral input requirements to produce advanced vehicles.

5.2 ASSUMPTIONS

The AMIGA model was run in five year periods from 2000 to 2030. Under the advanced motor vehicle scenarios, the reduction in total oil consumption was assumed to decrease domestic oil production and foreign crude oil imports in equal amounts. World oil price projections were obtained from the Energy Information Administration's (EIA) Annual Energy Outlook. Consumption and investment spending rise with income. The average income elasticity was assumed to be 0.8. Individual sectoral expenditure percentage changes could be more or less depending on a sector's own elasticity relative to the elasticities of other sectors.

The import shares of the advanced electric hybrid, electric, and fuel cell vehicles were expected to be 14 percentage points lower than conventional, internal combustion engine (ICE) vehicles. Ethanol, methanol, compressed natural gas (CNG), and liquefied petroleum gas (LPG) fueled vehicles were expected to have an import share that is four percentage points lower then ICE vehicles because these vehicles are more similar to conventional vehicles. These decreases in import shares for motor vehicles reflect expected improvement in the global competitiveness of U.S. motor vehicle manufacturers brought about by being the first to introduce new technologies. The import share reductions were phased in over the period 2000 to 2010.

5.3 RESULTS

Figure 6.5 of the *Five-Year Transportation Program Plan* shows how the advanced motor vehicle scenario will effect U.S. Gross Domestic Product (GDP) and employment. In 1992 constant dollars, GDP increases nearly $63 billion by 2010 and over $100 billion by 2020. Employment rises by more than 662,000 jobs in 2010 and by 775,000 jobs in 2020.

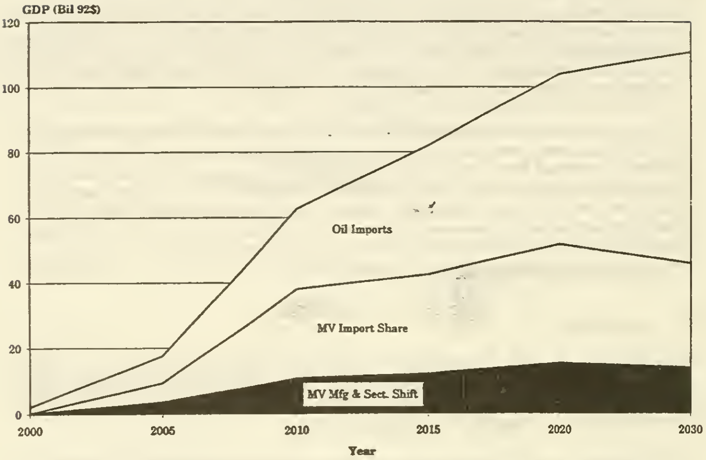
A table showing how the individual sectors in the U.S. economy are affected is included in the appendix. Agricultural grain production increases because ethanol fuel is taken to be derived from biomass which is produced in that sector. The organic chemicals sector increases because of the production of methanol for fuel cells. Natural gas and electricity are supplied from the utility sectors; hence their output increases. Gasoline production from refineries decreases along with the distribution and trade functions of gasoline marketing. Also noteworthy is the shift from conventional iron and steel components to lighter weight components in the manufacture of advanced vehicles.

There are three major reasons for the economic results that arise because of advanced motor vehicle production. In 2020, 50 percent of the GDP increase is due a decrease in the amount of money spent on oil imports. Those savings are then re-spent on other goods and services which have a higher domestic share of production. Approximately 35 percent of the GDP increase is the result of a higher domestic market share for U.S. manufactured motor vehicles. The remaining 15% is due to sectoral shifts in the composition and fuel use of the advanced vehicles and their increased cost.

Sensitivity tests were run with AMIGA in order to better understand the sources of GDP imports. These runs were used to calculate a GDP impact decomposition, as shown in Exhibit 12.

EXHIBIT 16:

SUMMARY GDP IMPACTS - 1994 EPACT SECTION 2021 ANALYSIS



6.0 SUMMARY AND OBSERVATIONS

The planning and analysis process used by the Office of Transportation Technologies was initially developed in conjunction with the EPACT Section 2021 mandate to develop a five-year Transportation R&D plan. Key methodology elements included: involvement of key program staff in strategic direction, the use of a variety of analytical tools to quantify market penetration and impacts, attention to technology cost analysis and peer review by industry and other agencies.

In the spirit of an on-going process, technical analysis areas that have received considerable developmental attention since 1994 include the following:

- Enhancements to market penetration analysis models,
- Continuing life-cycle cost analysis, and
- The performance of quantitative market penetration assessments for non-personal use (fleet) LDV markets, and heavy-duty transportation markets,

Other areas being addressed include: analytical techniques to evaluate impacts due to travel demand suppression measures, and market estimation analysis are based on consumer preference surveys from California. The development of analogous survey data representative of other geographic sectors, and, the nation as a whole will improve the credibility of the analysis results.

Analysis is intended to be representative of average national conditions. However, important regional variations in attribute values such as criteria pollutant emissions reduction benefits (e.g., important relative to EVs) are known to exist and should be considered in future planning efforts.

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APPENDIX

- IMPACTT Model Description (Excerpts)
- Greenhouse Gas Impacts Model Description (Excerpts)

ANL/ESD/TM-93

The IMPACTT Model: Structure and Technical Description

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December 1994

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AVAILABILITY OF COMPUTER SOFTWARE

This computer software has been developed under the sponsorship of the United States Department of Energy (DOE). Any further distribution by any holder of the software package or other data therein outside of DOE offices or other DOE contractors, unless otherwise specifically provided for, is prohibited without the approval of the Energy Science and Technology Software Center. Requests from outside the Department of Energy for DOE-developed computer software shall be directed to Energy Science and Technology Software Center, P.O. Box 1020, Oak Ridge, TN 37831-1020; telephone: (615) 576-2606.

THE IMPACTT MODEL: STRUCTURE AND TECHNICAL DESCRIPTION

by

M.M. Mintz, M.M. Tompkins, and J. Camp

ABSTRACT

The Integrated Market Penetration and Anticipated Cost of Transportation Technologies model, or IMPACTT, is a spreadsheet model that calculates the effect of advanced-technology vehicles and market penetration on baseline fuel use and emissions. Outputs include estimates of the quantity and value of oil displaced and emissions reduced by advanced-technology vehicles, the quantity of alternative fuels they consume, and the total incremental costs borne by purchasers of advanced-technology vehicles. In the current version of IMPACTT, up to eight fuel or engine technologies applicable to light-duty vehicles can be modeled by using a three-phase approach. First, the vehicle stock and miles traveled by the advanced-technology vehicle are determined. Second, assumptions about efficiency and fuel shares are used to estimate substitution-fuel use and oil displacement. Third, changes in emissions of carbon monoxide, nonmethane hydrocarbons, nitrogen oxides, and carbon dioxide are computed.

1 INTRODUCTION AND OVERVIEW

Argonne National Laboratory's (ANL's) Center for Transportation Research (CTR) developed the Integrated Market Penetration and Anticipated Cost of Transportation Technologies model (IMPACTT) to assist the U.S. Department of Energy's (DOE's) Office of Transportation Technologies (OTT) with program planning and development. IMPACTT is a spreadsheet model, operating in either an Apple™ or PC-compatible environment, that calculates the effect of advanced-technology vehicles and market penetration on baseline fuel use and emissions.

Outputs include estimates of the quantity and value of oil displaced and emissions reduced by advanced-technology vehicles, the quantity of alternative fuels they consume, and the total incremental costs borne by purchasers of advanced-technology vehicles. Estimates are based on exogenous projections of conventional vehicle sales, advanced-technology market penetration, and the characteristics of new conventional and advanced-technology vehicles. Vehicle characteristics include fuel efficiency; tailpipe emissions of nitrogen oxides (NO_x), carbon monoxide (CO), and nonmethane hydrocarbons (NMHCs); and incremental capital cost (i.e., the unit cost of a conventional vehicle less the unit cost of an advanced-technology vehicle). Annual petroleum displacement and emissions reduction are calculated by projecting the miles traveled by each model year's conventional vehicles, their petroleum use, and their emissions and then subtracting those projections from comparable projections for advanced-technology vehicles.

APPENDIX: "READ ME" FILE

IMPACTT (Integrated Market Penetration and Anticipated Cost of Transportation Technologies) was developed by Argonne National Laboratory's Center for Transportation Research to assist the U.S. Department of Energy's Office of Transportation Technologies (OTT) with program planning and development. Written in EXCEL 5.0 workbook format, IMPACTT is a spreadsheet model operating in either an Apple or PC/Windows environment. The current version consists of 16 worksheets — eight of them apply to all technologies (i.e., general worksheets); the other eight are specific to a particular technology or fuel alternative. The general worksheets are called INPUTS, SALES-MPG, EMIS INPUTS, VMT SUM, OIL SUM, EMIS SUM, EMIS RED SUM, and CON SUM.

GENERAL WORKSHEETS

To estimate the number of new advanced-technology vehicles on the road in a given year, market-penetration rates must be combined with an external forecast of new-vehicle sales by vehicle type, and vehicles must be tracked through a survival or vintaging procedure. The INPUTs worksheet contains user-supplied forecasts of market penetration and marginal cost for each advanced technology under examination and an emissions reduction value for each of three criteria pollutants (NO_x, CO, and NMHC). Each advanced technology contained on the INPUTS worksheet must have a technology-specific worksheet associated with it.

The SALES-MPG worksheet converts user-supplied forecasts of auto and light-truck sales and fuel economy into weighted averages for input into the stock model and calculations of oil displacement and fuel substitution. Note that users can input either EPA-test or estimated on-the-road fuel economy. Default forecasts of sales and EPA-test fuel economy were extrapolated from those in the *1994 Annual Energy Outlook* (DOE/EIA 1994). Default estimates of on-the-road fuel economy assume a 20% shortfall or gap from EPA test results, which are the default inputs (Mintz, Vyas, and Conley 1993).

The EMIS INPUTS worksheet contains default tailpipe emission rates by engine type and vintage and refinery and power-plant emission rates by fuel type. Expressed in g/mi, rates were computed from the EPA's MOBILE5a model. Within EMIS INPUTS, values for total light-duty vehicles are weighted as 60% autos and 40% light trucks. Default values for power-plant emissions are based on the year 2000 generation mix for New York City and southern California, the two locations likely to see the earliest EV market penetration. Default values are weighted by the relative share of VMT contributed by each of these two markets (Wang and Santini 1994).

Four of the general worksheets aggregate results across the technology-specific worksheets. The VMT SUM worksheet summarizes stocks and vehicle-miles displaced by all advanced-technology vehicles, while OIL SUM and EMIS RED SUM summarize total oil displacement and emissions reduction. Substitution-fuel use, again aggregated over all technologies considered in the particular scenario under examination, is summarized in the

CON SUM worksheet. For all four of these worksheets, results are reported annually for 1990–2030 and cumulatively (as appropriate) for 1990–2000, 1990–2010, 1990–2020 and 1990–2030. Outputs include advanced-technology vehicles on the road, oil displacement, VMT displacement, emissions reduction, value of emissions reduction, substitution-fuel use, and fleet-average fuel economy (miles/gallon gasoline equivalent) for the fleet of advanced-technology vehicles on the road.

Technology-Specific Worksheets

IMPACTT operates on a set of assumptions that define a particular scenario. The diversified scenario developed by DOE's Office of Transportation Technologies for its five-year program plan is the default case contained in the workbook file. That scenario required the use of eight technology-specific worksheets: HYBRID, ELECTRIC, FUEL CELL, FLEX ETHANOL, DED ETHANOL, CNG, LPG, and ICE. Thus, the default version of the model can accommodate up to eight different technologies.

Chief among the parameters used to define a particular scenario is the market penetration of the various advanced technologies — these rates are, in turn, a key component of the vehicle stock calculation. The default assumption in IMPACTT is that advanced-technology vehicles replace conventional vehicles on a one-for-one basis. The only exception is for advanced-battery electric vehicles, which are assumed to have a small (i.e., 10% of all electric vehicle sales), unique market demand. Thus, EV market penetration is multiplied by 0.9 in the default case, and EV electricity use is divided by 0.9 to account for unique or nonreplacement market demand.

The USAGE module estimates VMT per year as a function of vehicle age. The key parameters, miles per year for a new vehicle and a degradation rate, are the same for most light-duty-vehicle technologies. The key exception is the assumption of reduced miles-per-year by vehicle age for electric vehicles, which is embedded into the usage model calculation.

Several technology-specific parameters may be user-defined. These include gasoline-equivalent fuel economy, Btu content of the alternative fuel relative to gasoline, and efficiency relative to a conventionally fueled vehicle, all of which are used to compute fuel substitution (i.e., alternative-fuel use). For flex-fueled vehicles, five additional parameters are included in the calculation: alcohol share of reformulated gasoline, ethanol and methanol shares of fuel use, and ethanol and methanol fuel use. In the current version of IMPACTT, ethanol and methanol shares are estimated from an exogenous biofuels production forecast and an assumed split between bioethanol and biomethanol production. The default production forecast (contained in cells AO-13 through AV-57 of the DED ETOH worksheet) was developed by the Office of Transportation Technologies for its draft program plan. It assumes declining real prices for biofuels along with ethanol accounting for 100% of biofuels production. Thus, the default forecast assumes that ethanol shares are supply-constrained to the sum of current and new production capacity. Because the Office of Transportation Technologies has no ongoing methanol program, flex-fuel methanol and dedicated methanol vehicles are not modeled on the default file.

For electric vehicles, three additional parameters may be user defined. Annual usage may be set equal to that of conventional vehicles or modified to account for range limitations and differences in life expectancy. In the default case, electric vehicles are assumed to experience two-thirds the usage of conventional vehicles at all ages. Distribution and transmission efficiencies (cells Z12 and AA12 of the ELEC worksheet), which are used to account for losses between the power plant and vehicle, may also be user-defined. In the default case, 90% is assumed for distribution efficiency, and 95% is assumed for transmission efficiency. Note that calculations go back no further in the fuel cycle than the plant gate. In other words, fuel conversion efficiencies (e.g., to produce electricity or fuel-grade alcohol, or to compress natural gas) are not included in the current fuel substitution calculation. Total fuel-cycle energy use and emissions will be added to a subsequent version of IMPACTT.

Excerpts of Greenhouse Gas Emissions Model Documentation - Preliminary -

by Michael Wang, ANL

INTRODUCTION

Various transportation technologies using different transportation fuels are being promoted to help solve urban air pollution problems, limit climate changes caused by greenhouse gas emissions, and reduce U.S. dependence on imported oil. For these transportation technologies, while vehicle operations undoubtedly contribute to emissions and energy consumption, up-stream fuel production processes cause emissions and energy consumption as well. Since distinctly different primary energy sources and fuel production processes are involved in producing transportation fuels, up-stream emissions and energy consumption can be significantly different for different transportation technologies using different fuels. Thus, it is necessary to compare emissions and energy of different transportation technologies on a fuel-cycle basis.

In recent years, many studies have been conducted to estimate reductions in fuel-cycle emissions and energy consumption by various clean transportation technologies. These studies have yielded widely varying results regarding the magnitude of emission and energy use reductions. The significantly different results are caused primarily by differences among studies in estimating methodologies used, assumptions made about fuel production infrastructure, fuel sources, and projected emissions and energy efficiencies of future vehicle technologies and energy-producing technologies. Through this study, a criteria pollutant, greenhouse gas, and energy model (CPGEM) is established for calculating fuel-cycle emissions and energy use of various transportation technologies. CPGEM serves as a tool to compare fuel-cycle emission and energy use of various transportation technologies and to test the importance of assumptions regarding emissions and energy efficiencies on fuel-cycle emissions and energy use of various transportation technologies.

CPGEM calculates fuel-cycle emissions for five criteria pollutants [volatile organic gases (VOC), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matters with size smaller than 10 microns (PM_{10})] and three greenhouse gases [carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)]. Besides emissions, the model calculates the primary energy consumption when using different transportation fuels and the fuel-cycle petroleum displacement of using non-petroleum-based fuels.

Emissions of SO_x for all vehicle types are calculated by assuming that all sulfur contained in a given fuel is converted into SO_2. Emissions of CO_2 for all vehicle types are calculated with carbon contained in a given fuel minus the carbon contained in emissions of VOC, CO, and CH_4. For E85 and E100 vehicles, the amount of CO_2 emissions from ethanol is treated as being zero, since these CO_2 emissions originally come from the atmosphere through the photosynthesis process during biomass production.

MODEL LAYOUT

CPGEM is developed as a spreadsheet model in MS Excel 5.0. The model consists of 12 sheets, namely, *Emn_Factors, Fuel_Spec, Petroleum, NG, Biomass, Landfill_Gas, Coal, Uranium, Electricity, Vehicles, Results, and Graphs.* The *Emn-Factors* contains emission factors in grams per mmBtu of fuel combusted for various combustion technologies. These emission factors are used in other sheets for calculating emissions associated with fuel combustion in various fuel-cycle stages. The *Fuel_Spec* contains fuel specifications such as heat content, density, sulfur content, and carbon content for various fuels that are included in CPGEM.

The *Petroleum* calculates energy use and emissions for the stages from petroleum to RFG, low-sulfur diesel, LPG, and residual oil; the *NG* for the stages from NG to CNG, methanol, LPG, and hydrogen; the *Biomass* for ethanol production from corn, cellulosic biomass, and herbaceous biomass; and the *Landfill_Gas* for land-fill gases to methanol. The *Coal* and *Uranium* calculate emissions from coal mining to coal at power plants and from uranium mining to uranium at power plants.

The *Electricity* calculates energy use and emissions of electricity generation for a given electric generation mix and accounts for energy use and emissions during up-stream stages of production of residual oil, NG, coal, and uranium. The *Vehicles* calculates energy use and emissions of vehicle operations. The *Results* calculates Btu-per-mile energy use and grams-per-mile emissions for the whole fuel cycle from primary energy recovery to vehicle operations. The sheet then calculates reductions of per-mile energy use and emissions by various vehicle types relative to baseline GVs. The sheet also presents the allocation of fuel-cycle energy use and emissions among primary energy production, fuel production, and vehicle operations. The *Graphs* graphically presents the allocation of energy use and emissions among primary energy production, fuel production, and vehicle operations and the reductions of energy use and emissions by various vehicle technologies.

Within CPGEM, some cells present default assumptions used for fuel-cycle energy and emission calculations, while others are logic calculations. Users have the option to change any of the default assumptions. In CPGEM, the cells that contain critical assumptions are shaded so that readers can easily distinguish the critical assumptions from logic calculations.

RESULTS OF ENERGY USE AND EMISSIONS OF VARIOUS VEHICLE TECHNOLOGIES ESTIMATED WITH THE CPGEM

This section presents the results of energy use and emissions of various vehicle technologies calculated with CPGEM. In calculating fuel-cycle emissions, a 2000 model-year (MY) passenger car is assumed. It should be kept in mind that while many of the assumed vehicle technologies are mature for 2000 MY, some technologies are not. Immature vehicle technologies include EVs, HEVs, and FCVs. Immature fuel production technologies include cellulosic biomass to ethanol and herbaceous biomass to ethanol.

To approximate life-cycle emissions for the assumed 2000 MY car, fuel-cycle emissions are calculated in calendar year 2005. By 2005, the 2000 MY car should accumulate about half of its lifetime VMT. In this way, emissions of the 2000 MY cars in 2005 is approximately about the average of its lifetime emissions. For HEVs, it is simply assumed that half of the energy required is produced from the on-board engine-generator, and the other half comes from grid electricity. Even in 2005, combustion technologies both with and without emission controls can be applied to many up-stream stages. Where uncontrolled technologies are applicable, it is assumed that 80% of combustion technologies are controlled, and the remaining 20% are uncontrolled. Table 10 presents calculated per-mile energy use and emissions for all vehicle technologies included in CPGEM. Note that in the table a negative number means an emission saving credit.

Table 10. Fuel-Cycle Energy Use and Emissions of a 2000 MY Car in 2005

	Energy Use (Btu/Mile)		Emissions (Grams/Mile)					
	Total Energy	Petroleum	VOC	CO	NO_x	PM_{10}	SO_x	GHGs
Gasoline Vehicles								
Feedstock-Related	96	42	0.016	0.011	0.027	0.002	0.019	12
Fuel-Related	856	61	0.055	0.039	0.190	0.063	0.203	67
Vehicle Operation	3767	3767	1.199	8.686	0.635	0.033	0.018	290
Total	4719	3870	1.269	8.735	0.852	0.098	0.240	369
Diesel Vehicles								
Feedstock-Related	87	39	0.014	0.010	0.024	0.001	0.017	11
Fuel-Related	304	45	0.019	0.020	0.081	0.022	0.070	24
Vehicle Operation	3424	3424	0.384	1.100	1.092	0.121	0.078	282
Total	3815	3508	0.418	1.130	1.198	0.144	0.165	317
CNG Vehicles								
Feedstock-Related	330	7	0.010	0.053	0.160	0.001	0.012	30
Fuel-Related	198	0	0.001	0.007	0.069	0.005	0.112	31
Vehicle Operation	3767	0	0.283	5.212	0.603	0.021	0.001	250
Total	4294	7	0.293	5.272	0.833	0.027	0.125	311

M85 Vehicles: NG to Methanol								
Feedstock-Related	259	16	0.011	0.041	0.121	0.001	0.015	24
Fuel-Related	1740	95	0.044	0.141	0.299	0.022	0.075	81
Vehicle Operation	3622	939	0.734	7.383	0.603	0.022	0.007	272
Total	5621	1049	0.788	7.565	1.024	0.046	0.096	378
M85 Vehicles: Landfill Gases to Methanol								
Feedstock-Related	24	11	0.004	0.003	0.007	0.000	0.006	3
Fuel-Related	522	15	0.003	-0.255	0.278	-0.069	0.292	-425
Vehicle Operation	3622	939	0.734	7.383	0.603	0.022	0.007	272
Total	4167	965	0.741	7.131	0.888	-0.046	0.304	-150
M100 Vehicles: NG to Methanol								
Feedstock-Related	314	7	0.009	0.051	0.153	0.001	0.012	28
Fuel-Related	2043	107	0.040	0.176	0.335	0.009	0.030	86
Vehicle Operation	3587	0	0.671	6.949	0.572	0.021	0.003	268
Total	5943	113	0.720	7.176	1.060	0.031	0.045	382
M100 Vehicles: Landfill Gases to Methanol								
Feedstock-Related	0	0	0.000	0.000	0.000	0.000	0.000	0
Fuel-Related	412	0	-0.014	-0.353	0.307	-0.113	0.320	-591
Vehicle Operation	3587	0	0.671	6.949	0.572	0.021	0.003	268
Total	3999	0	0.657	6.595	0.878	-0.092	0.332	-324

LPG Vehicles: NG to LPG								
Feedstock-Related ·	330	7	0.010	0.053	0.161	0.001	0.013	30
Fuel-Related	214	72	0.023	0.033	0.079	0.004	0.014	16
Vehicle Operation	3767	0	0.345	6.080	0.603	0.021	0.000	277
Total	4310	79	0.378	6.166	0.842	0.027	0.026	323
LPG Vehicles: Crude to LPG								
Feedstock-Related	96	42	0.016	0.011	0.028	0.002	0.022	13
Fuel-Related	339	75	0.024	0.029	0.107	0.024	0.079	28
Vehicle Operation	3767	3767	0.345	6.080	0.603	0.021	0.000	277
Total	4202	3884	0.385	6.120	0.739	0.047	0.101	318
E85 Vehicles: Corn to Ethanol								
Feedstock-Related	371	185	0.020	0.090	0.211	0.011	0.052	57
Fuel-Related	1815	78	0.305	0.055	0.634	0.963	1.130	188
Vehicle Operation	3622	753	0.734	7.383	0.603	0.022	0.005	65
Total	5808	1015	1.058	7.528	1.449	0.997	1.188	309
E85 Vehicles: Cellulosic Biomass to Ethanol								
Feedstock-Related	364	278	0.026	0.106	0.233	0.011	0.023	40
Fuel-Related	2439	78	0.052	0.122	0.156	0.203	-0.064	-5
Vehicle Operation	3622	753	0.734	7.383	0.603	0.022	0.005	65
Total	6425	1109	0.811	7.611	0.993	0.236	-0.036	100

E85 Vehicles: Herbaceous Biomass to Ethanol								
Feedstock-Related	543	288	0.027	0.121	0.312	0.011	0.037	78
Fuel-Related	1687	78	0.047	0.092	0.149	0.142	0.004	10
Vehicle Operation	3622	753	0.734	7.383	0.603	0.022	0.005	65
Total	5851	1119	0.808	7.596	1.064	0.176	0.046	153
E100 Vehicles: Corn to Ethanol								
Feedstock-Related	440	220	0.021	0.110	0.257	0.013	0.060	68
Fuel-Related	2055	82	0.367	0.059	0.744	1.189	1.360	218
Vehicle Operation	3587	0	0.671	6.949	0.572	0.021	0.002	8
Total	6082	302	1.059	7.117	1.573	1.223	1.422	294
E100 Vehicles: Cellulosic Biomass to Ethanol								
Feedstock-Related	431	338	0.028	0.130	0.285	0.013	0.023	47
Fuel-Related	2836	82	0.051	0.143	0.147	0.238	-0.133	-24
Vehicle Operation	3587	0	0.671	6.949	0.572	0.021	0.002	8
Total	6854	419	0.750	7.221	1.003	0.272	-0.108	32
E100 Vehicles: Herbaceous Biomass to Ethanol								
Feedstock-Related	655	350	0.030	0.149	0.383	0.014	0.041	95
Fuel-Related	1895	82	0.046	0.105	0.138	0.162	-0.049	-4
Vehicle Operation	3587	0	0.671	6.949	0.572	0.021	0.002	8
Total	6137	432	0.746	7.203	1.092	0.197	-0.006	99

Electric Vehicles: U.S. Generation Mix								
Feedstock-Related	121	24	0.010	0.015	0.066	0.007	0.047	26
Fuel-Related	3414	164	0.003	0.046	0.579	0.030	0.984	241
Vehicle Operation	0	0	0.000	0.000	0.000	0.021	0.000	0
Total	3535	187	0.013	0.061	0.645	0.058	1.031	267
Electric Vehicles: California Generation Mix								
Feedstock-Related	154	13	0.007	0.020	0.069	0.004	0.023	19
Fuel-Related	2796	124	0.03	0.054	0.329	0.015	0.402	155
Vehicle Operation	0	0	0.000	0.000	0.000	0.021	0.000	0
Total	2950	136	0.010	0.074	0.398	0.040	0.424	174
Electric Vehicles: Northeast U.S. Generation Mix								
Feedstock-Related	154	21	0.011	0.016	0.066	0.007	0.048	23
Fuel-Related	3383	563	0.004	0.043	0.440	0.029	0.712	195
Vehicle Operation	0	0	0.000	0.000	0.000	0.021	0.000	0
Total	3538	583	0.014	0.059	0.506	0.058	0.761	218
Hybrid Electric Vehicles: U.S. Generation Mix								
Feedstock-Related	96	27	0.011	0.012	0.043	0.004	0.032	18
Fuel-Related	2019	104	0.022	0.037	0.361	0.038	0.569	146
Vehicle Operation	1375	1375	0.279	2.172	0.318	0.026	0.007	105
Total	3490	1506	0.311	2.220	0.722	0.068	0.608	268

Hydrogen Fuel-Cell Vehicles: NG to Hydrogen								
Feedstock-Related	165	3	0.005	0.027	0.080	0.001	0.006	15
Fuel-Related	1793	99	0.028	0.183	0.336	0.011	0.005	227
Vehicle Operation	1883	0	0.000	0.000	0.000	0.021	0.000	0
Total	3841	103	0.033	0.209	0.416	0.033	0.011	242
Methanol Fuel-Cell Vehicles: NG to Methanol								
Feedstock-Related	214	5	0.006	0.035	0.104	0.001	0.008	19
Fuel-Related	1392	73	0.027	0.120	0.229	0.006	0.020	59
Vehicle Operation	2446	0	0.263	0.869	0.064	0.021	0.002	179
Total	4052	77	0.296	1.023	0.396	0.028	0.030	257

Figures 2 through 9 show changes in fuel-cycle energy use and emissions of various transportation fuels relative to those of RFG. Figure 2 shows changes in total fuel-cycle energy use. Use of NG-based methanol and ethanol causes increases in total energy use. The increases are primarily due to low energy efficiencies of methanol and ethanol production. On the other hand, use of diesel, landfill gas-based methanol, LPG, EVs, HEVs and FCVs results in decreases in total energy consumption. The decreases for LPG and landfill gas-based methanol are mainly due to high conversion efficiencies for methanol and LPG production. The decreases for diesel, EVs, HEVs, and FCVs are caused by high energy efficiencies of these vehicle technologies.

Figure 3 shows petroleum displacement by particular fuels and vehicle technologies. Except for diesel and crude-based LPG, use of alternative fuels and technologies results in 60-100% reductions in petroleum use. Thus, use of these fuels or vehicle technologies is an effective way to reduce petroleum consumption by light-duty vehicles. Use of diesel reduces petroleum use by nearly 10%, simply because of the high energy efficiency of producing diesel at refineries. Use of crude-based LPG does not have much impact on petroleum use.

Based on Figure 4, all fuels and vehicle technologies reduce fuel-cycle VOC emissions. Use of methanol and ethanol results in 18-45% reductions in VOC emissions. Use of other fuels or vehicle technologies achieves more than 60% reductions. EVs and hydrogen FCVs almost eliminate VOC emissions.

Figure 5 shows fuel-cycle CO emission reductions by these fuels and vehicle technologies. Use of diesel, EVs, and FCVs helps reduce CO emissions by over 85%. EVs and hydrogen FCVs almost eliminate CO emissions. HEVs reduce CO emissions by over 70%. Use of CNG reduces CO emissions by about 40%. Use of LPG reduces CO emissions by about 30%. Use of methanol and ethanol reduces CO emissions between 15% and 25%.

Figure 6 shows that NO_x emissions can be decreased or increased, depending on the fuels or vehicle technologies used. Use of diesel, methanol, and ethanol results in increases in NO_x emissions. The largest increase occurs from corn-based ethanol. On the other hand, use of LPG, CNG, EVs, HEVs, and FCVs helps reduce NO_x emissions. The largest NO_x emission reductions occur from FCVs and the EVs with the California or the northeast U.S.

electric generation mix. NO_x emission reductions by the EVs with the U.S. generation mix and by HEVs are moderate.

As Figure 7 shows, the largest variation of emission changes exists for PM_{10} emissions. Use of diesel and ethanol causes increases in PM_{10} emissions. Use of ethanol can increase PM_{10} emissions by as much as ten times. The dramatic increases by use of ethanol result from the large amount of PM_{10} emissions during feedstock pretreatment and ethanol production at ethanol plants. Use of methanol, LPG, CNG, EVs, HEVs, and FCVs results in PM_{10} emission reductions. Use of methanol from landfill gases results in reductions between 150% to 200%; a reduction over 100% means that use of ethanol from landfill gases results in a net PM_{10} saving credit. The credit is from the PM_{10} emissions that are otherwise generated from burning of landfill gases.

Figure 8 shows that SO_x emissions can be increased or decreased, depending on the fuels or vehicle technologies used. Use of corn-based ethanol increases SO_x emissions by four to five times. This is because coal is assumed to be burnt to provide heat in corn-ethanol plants. Use of EVs and HEVs increases SO_x emissions by a large amount. With the California electric generation mix, the SO_x emission increase by EVs or HEVs is smaller. Use of landfill gas-based methanol increases SO_x by about 30%. This is because a large amount of SO_x emissions occurs during production of methanol from landfill gases. FCVs reduce SO_x emissions by 80-90%. Use of CNG, LPG, NG-based methanol, and ethanol helps reduce SO_x emissions. The reduction in SO_x emissions by diesel is due to a large amount of SO_x emissions being allocated to RFG at refineries. SO_x emission reductions by ethanol from cellulosic or herbaceous biomass are a result of the electricity credit earned in biomass-ethanol plants. A SO_x emission credit from the electricity credit is calculated from the amount of electricity generated and average SO_x emissions of U.S. electric generation system. Because of the SO_x credit, biomass-based ethanol has a fuel-cycle SO_x emission net savings.

Figure 9 shows changes in GHG emissions. GHG emissions here are global warming potential-weighted emissions of CO_2, CH_4, N_2O, VOC, CO, and NO_2. Except methanol from NG where GHG emissions are slightly increased, all fuels and vehicle technologies result in reductions in GHG emissions. The largest reductions occur for methanol from landfill gases. Because the CO_2 and CH_4 emissions that are otherwise generated from landfill gas combustion are taken into account as credits, use of landfill gas-based methanol results in a net savings of 40-50% of fuel-cycle GHG emissions. The large amount of GHG emission reductions by biomass-based ethanol is caused by the CO_2 emission credit associated with the electricity credit at biomass-ethanol plants.

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Brogan, J. and S. R. Venkateswaran. 1992. "Diverse Choices for Electric and Hybrid Motor Vehicles: Implications for National Planners," presented at the Urban Electric Vehicle Conference, Stockholm, Sweden, May 25-27.

Q215. Please provide a listing of the recipients of (i) the $2,283,000 in funding in FY 1995, (ii) the $2,032,000 in FY 1996 funding, and (iii) the requested level of $2,300,000 in FY 1997 for Evaluation, Planning, and Analysis.

A215. Funding recipients for FY 1995-FY 1997 are listed in the following table, where an x denotes that an recipient received funding.

		Received Funds			
No.	Major Recipient	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Argonne National Laboratory	x	x	x	N
2	Oak Ridge National Laboratory	x	x	x	N
3	National Renewable Energy Lab.	x	x	x	N
4	EA Engineering	x	x	x	Y
5	Abacus	x	x	x	Y
6	Lawrence Berkeley National Lab.	x			N

Q216. For those Evaluation, Planning, and Analysis funding recipients identified in the response to question 215 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A216. See the answer to question 215. Laboratory funding (Nos. 1, 2, 3, and 6) is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurement for the management of each laboratory.

Q217. On page 331 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated that in FY 1995: "Conducted a detailed program evaluation for the gas turbine program. This evaluation was done in concert with OPA."

Please provide a copy of that evaluation.

A217. The gas turbine evaluation is attached.

ASSESSMENT OF AUTOMOTIVE GAS TURBINES

November 1994

Prepared for
Advanced Propulsion Division
Office of Propulsion Systems
Office of Transportation Technologies
Energy Efficiency and Renewable Energy
U.S. Department of Energy

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LIST OF ABBREVIATIONS

AGATA	Advanced Gas Turbine for Automobiles (Sweden, France)
AGT	Advanced Gas Turbine (also Automotive Gas Turbine)
ATTAP	Advanced Turbine Technology Applications Program
CARB	California Air Resources Board
CGT	Ceramic Gas Turbine
CI	Compression Ignition (Diesel cycle engine)
CMC	Ceramic Matrix Composite
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOE	United States Department of Energy
ECC	Environmental Concept Car (Volvo)
EGR	Exhaust Gas Recirculation
FTP	Federal Test Procedure
GM	General Motors
HC	Hydrocarbon
HD	Heavy-Duty
LD	Light-Duty
LHR	Low-Heat-Rejection ("Adiabatic" diesel)
MITI	Ministry of International Trade and Industry (Japan)
NMHC	Non-Methane Hydrocarbons (Also reactive organic gasses, ROG)
NO_x	Oxides of Nitrogen
OEM	Original Equipment Manufacturer (Automaking company)
PEC	Petroleum Energy Center (Japan)
PM	Particulate Matter
PV-VG	Pre-Vaporizing, Variable-Geometry (Combustor)
R&D	Research and Development
RIT	Regenerator Inlet Temperature
RPD	Reference Powertrain Design
RT	Room Temperature
SFC	Specific Fuel Consumption
SI	Spark Ignition (Otto cycle engine)
TIT	Turbine Inlet Temperature
ULEV	Ultra-Low Emissions Vehicle (CARB emissions standard)
VW	Volkswagen

EXECUTIVE SUMMARY

This report presents the results of a U.S. Department of Energy sponsored assessment of automotive gas turbine technology. The goals of the assessment were to:

- Provide an update on the evolution and current status of automotive gas turbine powerplant technology

- Identify the potential benefits and drawbacks of automotive gas turbine powerplants and associated technologies

- Identify remaining technical and marketing barriers to the commercialization of automotive gas turbine powerplants.

The assessment led to the following findings about automotive gas turbine powerplants:

Experimental gas turbine powered vehicles have historically offered reasonable performance, but insufficient advantages over vehicles powered by conventional spark-ignition engines to justify production. The theoretical advantages of superior highway fuel economy, ultra-low emissions, multi-fuel capability, competitive specific power, superior torque characteristics (free-turbine engines), smoothness, and quietness of the gas turbine are well known. To date, however, technical challenges to actual achievement of the theoretical advantages, anticipated production costs, and relatively high idle and part-load fuel consumption have prevented these engines from displacing spark-ignition engines as prime movers in automobiles.

A ceramic gas turbine with an advanced combustor could achieve high efficiency and ultra-low emissions. One of the most compelling advantages of advanced gas turbines is that they could achieve emissions well below the California Ultra-Low Emissions Vehicle (ULEV) standards without any exhaust aftertreatment. When operated at the high temperatures that are possible with advanced ceramics, turbines could also achieve thermal efficiencies in excess of 40 percent.

Meeting future emission standards with conventional engines will be challenging. As emission standards continue to tighten, piston engines will require increasingly complex and costly measures to control their exhaust emissions. Further emissions reductions from conventional engines may also compromise performance and efficiency, unless breakthrough technologies in engine or powertrain design (such as hybrid vehicles) are developed. A significant investment in research and development will be required to develop the technology to enable conventional automotive engines to meet future emissions standards.

Gas turbines have superior alternative fuel capabilities compared to other heat engines. The continuous combustion process of the gas turbine eliminates the fuel octane or cetane requirements characteristic of piston engines. Gas turbines can operate on nearly any combustible gaseous or liquid fuel, and can achieve ultra-low emissions on many fuels. No other automotive heat engine under serious consideration today has a greater alternative fuel capability than the gas turbine.

The intrinsic efficiency of a hybrid powertrain could make a gas turbine powered vehicle competitive with conventional vehicles, even if advanced ceramics are not available. Studies have shown that hybrid vehicles powered by small gas turbine-powered generators (gensets) could achieve fuel economy approaching 30 km/L and emissions well below California ULEV standards, even when operating at relatively low peak temperatures. The future availability of ceramic components could further improve the performance of gas turbine powered hybrids.

Advanced high-temperature structural ceramic materials will be essential to the ability of a prime-mover automotive gas turbine to displace conventional engines. Peak turbine inlet temperatures (TIT) up to 1370°C are required to achieve sufficient fuel economy advantages over conventional engines to justify production of automotive gas turbines. Advanced ceramics appear to be the only suitable materials capable of achieving this performance at a reasonable cost. Ceramic gas turbines (CGT) with somewhat lower peak TITs, perhaps about 1200°C, might produce similar fuel economy to conventional engines, especially over higher-speed driving cycles with little stop-and-go driving. The ability to achieve ultra-low emissions from such engines might encourage their commercialization on the assumption that improved ceramics would later become available to allow increased operating temperatures and improved performance.

The costs of starting production of automotive ceramic gas turbines would be substantial but could be largely offset through careful planning. The cost of changing production lines to accommodate CGTs would be substantial and would probably be passed on to the consumer in the form of higher purchase prices. A significant portion of this cost could be avoided, however, if the creation of new production facilities were coordinated with plant expansions or phase-outs of old equipment.

The cost of developing emissions-compliant conventional engines could offset the startup cost penalty of the ceramic gas turbine. It will be expensive to develop and integrate the technology required to make conventional engines compliant with future emissions regulations. The cost of this development may offset the startup cost penalty of the CGT.

Ceramic gas turbine powerplants could be produced at competitive prices. Once manufacturing facilities are in place, production costs of CGTs could be similar to those of a ULEV-certified V-6 engine if production volumes are high enough. The low parts count of a CGT tends to offset the somewhat higher cost of its individual parts.

Conventional powerplants are firmly entrenched and will not be easily displaced. Conventional four-stroke spark-ignition powerplants are a mature technology and do a fine job of fulfilling the expectations of most vehicle owners and drivers. The automotive industry has nearly a century of experience with these engines. The gas turbine must offer dramatic advantages compared to conventional powerplants to be even considered for production. Otherwise, the automakers could not justify abandoning their capital and intellectual investment in this technology. Improved four-stroke, and possibly two-stroke spark-ignition engines will continue to provide serious competition and a moving target for gas turbines. Hybrid vehicles and vehicles powered by fuel cells could also outperform the CGT and may beat it to the marketplace.

Service technicians will require a significant, but not prohibitive, amount of supplemental training and service equipment. As with any new powerplant, service technicians will need to acquire additional knowledge, tools, and diagnostic equipment. The experience of the airline industry illustrates that such changes are feasible, if there is a sufficient incentive.

A market is anticipated for vehicles powered by ceramic gas turbines, if the manufacturers decide to produce them. In order for manufacturers to initiate production of CGT-powered vehicles, the CGT will have to demonstrate superior performance and competitive economics to conventional engines. If the CGT is able to do so, the operating economy, quietness, smoothness, torque, and perception of "high-tech" could be expected to appeal to many potential customers. Ultimately, if turbine-powered vehicles can provide competitive overall performance at a competitive cost (at least on a life-cycle basis), then consumers will welcome them.

Other technologies must also be evaluated. Hybrid vehicles using conventional engines would likely achieve better fuel economy than vehicles powered solely by ceramic gas turbines, although their emissions might be higher. Fuel economy of hybrids powered by metallic or ceramic gas turbines could be better still, while maintaining ultra-low emissions. Fuel cells are still in the early stages of development, but could be superior to any heat engine when the technology matures.

1.0 INTRODUCTION

This report presents the results of a study of automotive gas turbine powerplants. The current state of the art is assessed, and remaining barriers to commercialization are explored. Representative highlights of historical automotive gas turbine development efforts are also briefly recounted for context. Throughout the report, it was assumed that the reader has a basic understanding of the components and method of operation of single-shaft and free-turbine simple-cycle gas turbines with exhaust heat recovery.

1.1 PURPOSE, OBJECTIVES, AND SCOPE OF REPORT

This study was commissioned by the Office of Transportation Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy (DOE) to provide an independent assessment of automotive gas turbine (Brayton cycle) powerplants. Its purpose is to fulfill three primary objectives:

- Provide an update on the evolution and current status of automotive gas turbine powerplant technology
- Identify the potential benefits and drawbacks of automotive gas turbine powerplants and associated technologies
- Identify remaining technical and non-technical barriers to the commercialization of automotive gas turbine powerplants.

Where helpful, the benefits and drawbacks of automotive gas turbines are compared to competitive powerplants, specifically conventional spark- and compression-ignition engines. Fuel cells are also compared where information on this developing technology is available. Barriers to commercialization of gas turbines are examined because any potential benefits of automotive gas turbine powerplants cannot be realized unless large numbers of gas turbine-powered vehicles are produced, sold, and used.

The primary information sources reviewed for this study included major reports on automotive gas turbines and competing powerplant technologies, relevant literature in major technical databases (Society of Automotive Engineers International, American Society of Mechanical Engineers), and personal contacts with representatives of both research and manufacturing organizations. Several experts in gas turbine and other automotive powerplant technologies and their practical applications provided an independent technical review of the draft report. Their names and those of other contributors are listed in Appendix A.

This study is a review and discussion of publicly available information, rather than a rigorous engineering analysis. Worldwide developments are reported, but the emphasis is on efforts supported by DOE. Readers desiring greater technical detail are encouraged to consult the references at the end of each chapter.

Several aids to the reader have also been provided in this report. These include a list of abbreviations, a table summarizing the study findings (Appendix B), selected conversions between U.S. Customary and Metric units (Appendix C), and a glossary.

1.2 CRITERIA FOR ASSESSING AUTOMOTIVE POWERPLANT TECHNOLOGIES

The gas turbine was evaluated and compared to competing automotive powerplants using criteria organized under the broad categories of performance and costs.

PERFORMANCE

- *Exhaust Emissions*. Emissions from the tailpipe of a vehicle of unburned hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x). Secondary consideration is given to emissions of sulfur compounds and particulates. Carbon dioxide (CO_2) emissions, which depend primarily on the quantity of fuel consumed (directly related to powerplant efficiency) and secondarily on the chemical composition of the fuel, were not specifically addressed.

- *Alternative Fuel Capability*. The ability of the powerplant to operate satisfactorily on different fuels, in either a dedicated or multi-fuel mode.

- *Specific Power and Power Density*. The ratio of rated peak power output of a powerplant to its mass and volume, respectively. Typical units for specific power are kilowatts per kilogram (kW/kg) and typical units for power density are kilowatts per liter (kW/L). It should be noted, however, that differences in engine torque-speed characteristics and transmission designs may allow engines of different peak power levels to provide equivalent performance in a vehicle.

- *Energy Efficiency*. The ratio of the useful power output of a powerplant to the rate that chemical energy is supplied in the form of fuel. For convenience, and because it is desirable to compare the efficiency of powerplants under realistic driving conditions, the efficiency is often expressed as the rate of fuel consumption (i.e., kilometers per liter) during a standardized "driving cycle," such as the Federal Test Procedure (FTP), or under other specific conditions.

COSTS

- *Tooling/Startup Costs*. The costs to the manufacturer of obtaining tooling and beginning production of a new engine or vehicle design.

- *Manufacturing Costs*. The costs of building individual units once production has begun.

- *Purchase Cost*. The cost of obtaining a new vehicle. Manufacturing costs are passed on to the consumer in the purchase cost. Tooling and startup costs are projected over the first several years of production of the vehicles and are also passed on to the consumer in the purchase cost.

- *Reliability, Durability, Life Expectancy, and Scheduled Maintenance Requirements*. Interrelated criteria expressing the burdens of scheduled and random maintenance-related costs and inconveniences. A vehicle's useful life can be considered complete when it costs more to keep fixing it than to replace it, or when it no longer performs its mission adequately.

- *Operating Costs*. The combined cost of fuel, oil, and maintenance. Depreciation may also be considered an operating expense.

- *Infrastructure Needs*. Includes costs of providing the necessary infrastructure support such as roads, refueling stations, and parking facilities.

- *Service/Maintenance Industry Requirements*. The amount of supplemental training required for service and maintenance personnel. Also includes investment in special diagnostic equipment and servicing tools.

- *Safety-Related Liabilities*. The potential for a powerplant or its auxiliaries to contribute directly or indirectly to personal injury or property damage during normal or abnormal (including accidents) operation.

1.3 BARRIERS TO COMMERCIALIZATION OF ALTERNATIVE AUTOMOTIVE POWERPLANTS

Besides being competitive in the criteria above, a successful alternative automotive powerplant must overcome several additional barriers:

- *Technology Barrier*. The immature state of component designs, system designs, materials, and manufacturing technologies available to create a new powerplant that is competitive in performance and cost with conventional powerplants.

- *Institutional Inertia Barrier*. The reluctance of manufacturers to abandon their massive intellectual and property investments in conventional powerplants and assume the risk of investing heavily in a new technology, despite potential future success.

- *Marketability Barrier*. The risk that consumers will not want to purchase vehicles with an alternative powerplant, even if they are available at dealers and competitive with other vehicles based on the above criteria. Also, the uncertainty for manufacturers regarding potential warranty and liability costs.

2.0 AUTOMOTIVE GAS TURBINE R&D AND ACCOMPLISHMENTS TO DATE

A significant amount of research and development (R&D) on automotive gas turbines has been undertaken worldwide. Many of the world's major automakers have experimented with turbine powerplants, and some of these efforts are continuing today. Several of these programs received technical and financial assistance from aerospace partners and/or national governments. Currently, R&D efforts are underway in the United States, Japan, and Europe. Representative highlights of some of these efforts are described below.

2.1 UNITED STATES R&D

Research and development on automotive gas turbine powerplants has been underway in the United States for more than 40 years. All of the major U.S. automakers and several other organizations have experimented with turbine power at one time or another. Descriptions of several significant R&D efforts are presented in no particular order below.

Chrysler. Chrysler Corporation began R&D on automotive gas turbines shortly after World War II. The first generation Chrysler turbine vehicle was unveiled in 1953. This vehicle was driven from New York City to Los Angeles in 1956. In 1958, a vehicle with a second-generation engine was driven on a round trip between Detroit and New York City. This trip demonstrated the significant improvements in fuel economy and drivability offered by using variable-geometry turbine nozzle vanes. Later, a vehicle with a third-generation engine was driven from New York City to Los Angeles. During the trip, which took place primarily on the open road, this vehicle demonstrated better fuel economy than the equivalent conventional vehicle that was driven alongside it for comparison.[1]

Responding to public interest, Chrysler decided to build a fleet of 50 turbine-powered cars. Beginning in late 1963, the vehicles were loaned to drivers (chosen from people who had written to Chrysler indicating interest in turbine vehicles) to use as their personal vehicle for six months. After the six-month period, the cars were loaned to a new group of drivers. Thus, approximately 200 drivers, plus their families and friends, experienced driving and "owning" a gas turbine powered vehicle during the two-year demonstration.

The Chrysler engines were free-turbine, regenerative designs with all major components made from metals. Despite its favorable reception and considerable technical success, the Chrysler automotive gas turbine program was dropped due to the higher cost of manufacturing and poorer urban fuel economy of these engines compared to conventional spark-ignition (SI) engines.[2]

Ford. The Ford Motor Company developed a number of light- and heavy-duty automotive gas turbines over a period of three and a half decades beginning in the early 1950s. The early Ford gas turbine models 701, 702, 704, and 705 developed between 1952 and 1965 for passenger cars and trucks did not meet design performance goals and were discontinued, although the model 705 was installed in an experimental heavy-duty truck and successfully driven nonstop from San Francisco to New York City.

Later Ford efforts were much more successful. In 1964, Ford began development of the model 706 passenger car gas turbine. Installed in a test vehicle, it exceeded the program's acceleration and fuel economy goals. The project was considered a success technically, but the high projected production costs relative to a comparable (non-emission-controlled) V-8 piston engine led to cancellation of the program in 1967.

The Ford model 707 heavy-duty gas turbine actually saw limited production in the early 1970s. In addition to highway trucks, the engine was adapted to several industrial applications as well, and approximately 200 model 707 turbines were eventually produced. Due to higher-than-expected production costs and problems with the ceramic regenerator cores, the regenerator seals, and the electronic fuel control systems, the production program was terminated in June 1973. At least some of the individuals involved felt that the program had been rushed, and could have been notably more successful if it had been conducted on a longer schedule, even with the same overall funding level.[3] Research continued with some Government support until 1982, during which time the regenerator and fuel control system problems were resolved, although production never resumed. Operators of the turbine-powered trucks preferred them to their regular diesel-powered trucks because of the turbine's superior power, smoothness, quietness, and ability to drive away moments after starting.

Ford also initiated an R&D program in 1967 to develop a ceramic-based gas turbine engine. Support from the Government became available beginning in 1971. By the end of the program in 1978, the stationary ceramic parts were beginning to show promise of adequate durability at 1370°C temperatures. The ceramic turbine rotors, however, did not survive more than a few tens of hours at these temperatures and were considered to be the pacing component in ceramic gas turbine (CGT) technology.

General Motors/Allison. General Motors Corporation (GM) and its Allison Gas Turbine Division (Allison became independent on December 1, 1993 under the name Allison Engine Company) have created approximately 50 vehicles powered by gas turbine engines during the last several decades. GM's first operational turbine-powered car made its debut in 1952. A series of futuristic "Firebird" concept cars (different from the later production Pontiac Firebird) powered by regenerative gas turbines were introduced at auto shows in 1952, 1956, and 1958. During the 1960s, several experimental turbine-powered buses and heavy-duty trucks were built and tested. This effort peaked in the 1970s when at least 24 vehicles were built with 224 kW Allison 404 regenerative heavy-duty turbines.[4] GM and Allison also produced a number of light-duty vehicles powered by experimental gas turbine engines. Several AGT-1 engines were installed in cars for testing during the 1970s and early 1980s. A later engine, the AGT-5, which is a metal-turbine engine with a ceramic rotary regenerator, has been demonstrated publicly in the Chevrolet Express concept vehicle. AGT-5 engines have also been dynamometer tested with ceramic hot-section components.[5]

General Motors and Allison have been developing a new automotive gas turbine. It is a free-turbine design with ceramic hot-section parts and significantly better performance than the research engines developed under the DOE-sponsored Advanced Gas Turbine and Advanced Turbine Technology Applications projects described below. Little other information regarding this engine is publicly available.[6]

General Motors has recently been awarded a contract by DOE to develop a hybrid vehicle. This vehicle will feature a generator set (genset) powered by a small, advanced-technology CGT. A running prototype vehicle is expected to be completed around 1998, with possibility for production a few years after that.[7]

STP/Paxton. In 1967, a unique and controversial turbine-powered race car, built by the Paxton Division, STP Division, of Studebaker Corporation, established 18 new track records while leading the Indianapolis 500 for 173 of 200 laps. A transmission failure three minutes short of a convincing victory forced the car to withdraw from the race. The simple-cycle free-turbine engine was based on the highly successful Pratt and Whitney PT6 aviation turboprop engine.[8]

Williams. Under a U.S. Army contract, Williams Research (now Williams International) installed a simple-cycle gas turbine in a Jeep, c.1962. The project was dropped when defense resources were diverted toward the growing conflict in Vietnam.

Williams was awarded a National Aeronautics and Space Administration/Energy Research and Development Administration contract in the mid-1970s to develop a fuel-efficient automotive gas turbine engine. This program led to the Williams WR26 automotive gas turbine engine, a metal-based engine except for its dual ceramic rotary regenerators. The WR26 was installed in an American Motors Hornet car and successfully tested in New York City by the Environmental Protection Agency in the late 1970s. Based on reported power, weight, and size, the approximate specific power of the WR26 was 525 W/kg and power density was 233 W/L.[9]

Garrett, Mack, KHD. A team composed of Garrett, Mack Truck, and Klockner Humboldt Deutz (KHD), began a program in 1972 to develop a 335-485 kW gas turbine engine for use in heavy-duty trucks. This effort produced the GT 601, a free-turbine all-metal engine with a fixed boundary recuperator. Several engines were built during the program and tested extensively. More than 7,000 hours of operation were accumulated, including more than 2,000 hours in highway trucks. These engines demonstrated the feasibility of fixed boundary recuperators along with superior torque compared to diesels of similar rated power, easy cold starting, and the ability to survive limited foreign object ingestion.[10]

DOE, Allison, Garrett. The Advanced Gas Turbine Program (AGT) was initiated in the early 1980s as a cooperative effort between DOE and two powerplant development teams. One team was led by the Allison Gas Turbine Division of General Motors with the support of its Pontiac division, and the other was led by the Garrett Turbine Engine Company (now

Garrett Auxiliary Power Division of AlliedSignal) with Ford Motor Company. Several ceramic component suppliers were also involved. The goal of the AGT program was to develop the technology for automotive gas turbines to the point where the automakers (sometimes referred to as original equipment manufacturers, or OEMs) could make informed decisions on whether to commercialize automotive gas turbines. Program goals included a fuel economy improvement of 30 percent relative to contemporary SI engines. Studies by the design teams indicated that the fuel economy goal required operation at peak turbine inlet temperatures (TIT) of 1288-1370°C[11], which meant that the hot-section components would have to be made from advanced ceramic materials.

The AGT teams independently designed two CGT engines, although most component development and testing was conducted in laboratory rigs rather than complete engines. The Allison team designed their AGT100 engine with a free power turbine while the Garrett team selected a single-shaft configuration for their AGT101 engine. Peak design turbine inlet temperatures were 1288°C and 1371°C, respectively. Both engines used ceramic rotary regenerators for exhaust heat recovery.

By the completion of the AGT program in 1987, it was clear that ceramic technology was the weak link in the capabilities of high-performance automotive gas turbines. Therefore, a new program was initiated. The Advanced Turbine Technology Applications Project (ATTAP) was a five-year program, begun in mid-1987, to continue essential R&D in ceramic materials and components and their application to the gas turbine engine. Although some particularly successful CGT tests were run under the AGT program using ceramics from foreign suppliers, ATTAP focused on refining U.S. ceramic technology.[12] Improvements in ceramic materials during ATTAP are summarized in Chapter 3.0.

NoMac. NoMac Energy Systems is developing an all-metal recuperated gas turbine with a shaft-mounted electric generator. The complete genset will be used to power a hybrid vehicle. NoMac's engine is designed to use inexpensive materials and will therefore operate at a conservative TIT of 816°C. Future evolutionary improvements might gradually raise this temperature. The recuperator offers high effectiveness, high reliability, and low manufacturing costs due to the simplicity of its innovative design.[13]

Despite the low TIT, fuel economy will still be high due to the high recuperator effectiveness and the inherent efficiency of hybrid operation. Fuel efficiencies in excess of 30 km/L are considered possible for a small car cruising at a steady 100 km/hr.[14] Emissions from the NoMac turbine's catalytic combustor are projected to be ultra-low. Additional information about the performance of the NoMac engine and its catalytic combustor is presented in Chapter 3.0.

2.2 FOREIGN R&D

Japanese and European automakers have also experimented with automotive gas turbines. Most of the recent efforts have concentrated on ceramic engines.

2.2.1 Japan

Japanese R&D on automotive gas turbines has been underway since the late 1960s. The Japanese government has recently become involved in supporting these efforts. Descriptions of several significant R&D efforts are presented in no particular order below.

MITI, PEC, and JARI. A significant cooperative effort in automotive ceramic gas turbines is currently underway in Japan. This is a seven-year program that was started in June of 1990 with the goal of developing an automotive CGT. The total estimated funding for the project is 16 billion yen or about $123 million. The sponsoring government agency is MITI, the Ministry of International Trade and Industry. The Petroleum Energy Center (PEC) functions as an agent of MITI and manages the program. PEC has combined all CGT development under a single contract with the Japanese Automobile Research Institute, which includes the "Big Three" Japanese manufacturers (Toyota, Mitsubishi, and Nissan) and a number of other automotive- and ceramics-related companies.[15] A parallel program is also underway to develop a 300 kW stationary industrial CGT.[16]

The program's automotive CGT is a single-shaft engine with twin rotary ceramic regenerators. Development goals include:

- Thermal efficiency of not less than 40 percent
- Peak TIT of 1,350°C
- Rated power output of 100 kW
- Maximum speed of 110,000 rpm
- Compliance with Japanese emissions regulations.[17]

A 100-hour test stand demonstration is planned for the end of 1996.[18]

The 1996 demonstration engine will most likely use monolithic ceramics due to their more advanced state of development. A significant amount of research is underway, however, on ceramic matrix composites (CMC). In CMCs, the ceramic matrix is reinforced by carbon fibers, ceramic fibers, ceramic particles, or in-situ-grown elongated grains of the matrix material, giving CMCs improved fracture toughness compared to monolithic ceramics.[19]

Toyota. Of the Japanese manufacturers, Toyota appears to have done the greatest amount of gas turbine R&D. Toyota has installed a 246 kW regenerated all-metal free-turbine engine dubbed the GT31 in a bus, which is used as a demonstration vehicle. The GT31 is reportedly much quieter than the standard diesel bus engine. Toyota is also developing a 150 kW automotive engine called the GT41. The GT41 is a free-turbine design and currently uses no ceramics. Toyota plans to develop a ceramic version of the GT41, although it has not yet done so.[20]

Toyota will gain some ceramics experience with its new 2JZ family of SI engines that use ceramic turbocharger rotors.[21] Although turbocharger rotors experience lower thermal and mechanical stresses than gas turbine rotors, the experience gained from manufacturing tens of thousands of them will benefit later CGT manufacturing efforts. The greatest benefits of this manufacturing experience will be to reduce the cost of future ceramic parts production and to establish a data base on the in-service performance and reliability of ceramic components.

Mitsubishi. Mitsubishi began studies of a gas turbine for trucks around 1969. Due to the unavailability of high-performance ceramics at the time, its first engine, built in the mid-1970s, was an all-metallic design. Mitsubishi has been tracking the improvements in performance of ceramic materials over time, but has not yet built a ceramic version of this engine.[22]

Nissan. Nissan designed a metallic gas turbine that was installed in a bus in 1969. Work began on a 100 kW ceramic gas turbine in the mid-1970s. The primitive status of ceramic technology at that time hindered progress, especially with the radial-flow turbine wheel. This project was apparently dropped in the early 1980s. Nissan has since developed ceramics for the less challenging application of turbocharger rotors. Over 500,000 vehicles have been delivered since 1985, with ceramic turbocharger rotors exhibiting excellent performance and reliability.[23]

2.2.2 Europe

European automakers have developed automotive gas turbines for both prime-mover and hybrid installations. Descriptions of several significant R&D efforts are presented in no particular order below.

Volvo/United Turbine. Volvo and its subsidiary, United Turbine, have built a vehicle they call the "Environmental Concept Car" (ECC). The ECC prototype is a fully-operational dual-mode hybrid vehicle that uses a low-NO_x regenerated single-shaft all-metal turbine to power a 39 kW, 90,000 rpm electric generator. The generator supplies electric power to charge and/or supplement the vehicle's nickel-cadmium batteries. All motive power is transferred to the wheels by an electric drivetrain that is capable of supplying up to 70 kW of peak power (56 kW continuous). The ECC can be operated in any of three modes: electric (turbine off), dual-mode (turbine automatically cycles on and off as needed to maintain the state of battery charge within predetermined limits), or power-assist (turbine runs constantly, adding its output to battery output and making higher vehicle performance available). When running, the turbine operates at a constant speed chosen to provide the best tradeoff of power and efficiency. Consequently, the ECC is immune to the traditionally poor idle and part-load fuel economy of prime-mover turbine applications.[24,25,26] Benefitting from approximately $15 million of support from the Swedish government, some 500 hybrid cars with a powertrain based on the ECC are expected to be on the road there within two years.[27] United Turbine also reported road tests of a ceramic turbine engine in 1982, but emissions and fuel economy data were not included.[28]

Volvo is also involved in a venture with several Swedish and French partners to develop an "Advanced Gas Turbine for Automobiles" (AGATA). As originally conceived in 1987, the AGATA program was dedicated to developing a 100 kW gas turbine to serve as the prime mover in an otherwise conventional powertrain. Shortly thereafter, however, the AGATA partners decided that the gas turbine was more suited to high-speed turbogenerator applications in hybrid vehicles than to primary automotive propulsion.

AGATA was therefore reoriented in 1992 as a four-year program with the goals of developing the critical components for advanced gas turbine gensets: catalytic combustors, ceramic turbine wheels, and fixed-boundary ceramic recuperators. Design goals include a mechanical output of 60 kW, a TIT of 1350°C, ultra-low emissions, and a specific fuel consumption (based on diesel fuel) of 200 g/kWh. Using a lower heating value of 43,200 kJ/kg for diesel fuel, this is equivalent to a thermal efficiency of 41.7 percent. A prototype genset meeting these goals should be available by 1997-1998, shortly after the completion of the AGATA program in 1996.[29]

Daimler-Benz. Daimler-Benz drove a CGT-powered Mercedes sedan 660 km from Stuttgart to Brussels to attend an international gas turbine conference in 1990. Maximum TIT of this engine can reach 1350°C during acceleration. Emissions during the test drive were reportedly below 1995 (sic) California standards, even though the engine had not yet been optimized for fuel economy or emissions. Fuel economy was still reportedly within 20 percent of a comparable vehicle powered by a diesel engine.[30]

Volkswagen. Volkswagen installed its VW-GT 150, a 100 kW free-turbine engine using a ceramic rotary regenerator and an all-metal hot section, in an Audi RO 80 sedan in about 1980. Even without the benefit of ceramic hot-section components, the composite fuel economy of the test vehicle was competitive with equivalent contemporary SI-powered vehicles (highway mileage was better, city mileage was poorer). Emissions were in compliance with contemporary standards, despite the fact that the combustor had not been optimized. The GT 150 was also significantly quieter than the baseline SI engine.[31]

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3.0 AUTOMOTIVE GAS TURBINE TECHNOLOGY ASSESSMENT

Automotive gas turbines must be able to compete with both conventional automotive powerplants and several alternative powerplants that might be adopted instead. Compared to these competing automotive powerplants, gas turbines have numerous advantages, but face some significant challenges with regard to:

- Powerplant Performance and Costs
- Ceramic Materials Technology.

The assessment findings are discussed below. They are also summarized in table form in Appendix B.

3.1 POWERPLANT PERFORMANCE AND COSTS

The most important considerations for an automotive powerplant are performance and costs. Performance of the powerplant must be at least adequate for its intended mission, and costs must be competitive with alternative powerplants. Any additional costs for an alternative powerplant must be balanced by a perception of increased value.

3.1.1 Performance

The performance of automotive powerplants can be quantified in many ways. For this assessment, four measures of performance have been used. In order of advantages of gas turbine powerplants over conventional spark-ignition engines, they are: exhaust emissions, alternative fuels capability, specific power and power density, and efficiency.

3.1.1.1 *Exhaust Emissions*

As the number of vehicle miles traveled continues to increase year after year, it will become increasingly important for vehicles to produce very low emissions of harmful exhaust pollutants. This is an area where the gas turbine holds a fundamental advantage over conventional reciprocating internal-combustion engines.

General Considerations. Emissions of unburned hydrocarbons (HC) and carbon monoxide (CO) are due to incomplete combustion caused by relatively low combustion temperatures (below 800-1100°C) and/or insufficient oxygen. Emissions of oxides of nitrogen (NO_x), on the other hand, increase rapidly as temperatures approach 1650°C or higher, especially in the presence of excess oxygen due to a lean mixture.

To achieve the best compromise between the conflicting requirements for minimizing these harmful emissions, the combustion process should occur in a lean air-fuel mixture at a consistent temperature just below the temperature where the NO_x formation rate begins to increase rapidly. (This is also consistent with the desirability of operating at a high peak cycle temperature to increase thermal efficiency). The ideal combustion temperature may depend on the relative importance of minimizing each type of pollutant and could therefore conceivably be different for engines operated in different geographical regions, e.g., California.

Emissions of carbon dioxide (CO_2) are determined by two factors: the relative carbon content of the fuel, and the overall efficiency of the powerplant and vehicle (a more efficient vehicle will burn less fuel on a given trip and will therefore produce less CO_2). Although it is not a toxic gas, CO_2 is believed to contribute to global warming. Emissions of sulfur compounds, which lead to acid rain, are a direct result of burning sulfur-containing fuels and can also be minimized by increasing efficiency and using fuels with less sulfur content.

Gas Turbines. The continuous combustion process of the gas turbine offers the possibility of precise combustion control to minimize exhaust emissions. This potential has not always been realized, however. Traditionally, gas turbines, especially for aircraft, have used diffusion-type combustors. In this type of combustor, fuel is sprayed directly into the combustion zone where most of it is burned before it can fully vaporize and mix with the combustion air. The result is widespread stoichiometric burning at the surface of liquid fuel droplets, leading to very high localized temperatures and consequent formation of NO_x, even though the average temperature of the gas leaving the combustor is lower. Diffusion combustors are also unable to maintain stable combustion at NO_x-limiting lean air-fuel ratios. Although diffusion combustors are attractively simple, their unacceptably high NO_x emissions preclude their use in automotive applications.

To control these emissions, the combustors that have been designed for most major recent automotive gas turbine projects employ "pre-vaporization" of the fuel and lean combustion. Introduction of the fuel and primary air well upstream of the combustion zone provides the fuel a relatively long time to vaporize and ensures that the air-fuel mixture will be nearly homogenous by the time it is burned. This eliminates stoichiometric burning of fuel droplets and, combined with a lean air-fuel ratio, dramatically reduces peak combustion temperatures and NO_x formation. Stable combustion at very lean air-fuel ratios is made possible by the homogeneity of the mixture combined with the relatively high combustor inlet air temperatures made possible by the use of ceramic components. The uniform combustion and excess air also ensure almost complete oxidation of HC and CO into carbon dioxide (CO_2) and water vapor, the ideal combustion by-products of a hydrocarbon fuel. Particulate emissions from these automotive gas turbines are also very low.

State-of-the-art automotive turbine combustors also have the ability to change their combustion-zone geometry, either by physically moving combustor components in relation to one another, or by varying the quantities of fuel and air that are injected at various locations. The second approach may be the best for automotive applications since it requires no moving high-temperature parts. Variable-geometry allows the combustion process to be continually adjusted to match the various steady-state and transient operating conditions that are experienced in automobiles.

Catalytic combustors offer another way to achieve ultra-low emissions. In this type of combustor, the fuel and air are reacted on a catalyst-coated substrate at a lower temperature than if the fuel were simply burned. A catalytic combustor can maintain stable combustion at air-fuel ratios that are too lean to support normal combustion. The relatively low combustion temperature prevents significant formation of NO_x, and the action of the catalyst promotes nearly complete oxidation of HC and CO into CO_2 and water vapor. Catalytic combustors also have no moving high-temperature parts.

Both combustor types control the formation of regulated emissions in the powerplant itself. Gas turbines using these combustors can comfortably satisfy all existing and proposed emissions standards without any sort of exhaust aftertreatment. Emissions levels significantly below the 1997 California Ultra-Low Emissions Vehicle (ULEV) standards have been demonstrated in laboratory tests of prototype gas turbine combustors running on a variety of fuels. The ULEV standards are the most stringent exhaust emissions standards that have ever been adopted in the United States; beginning in 1997, 2 percent of the vehicles sold in California must meet the standard, with the percentage increasing to 15 percent by 2003. Exhibit 3-1 compares the projected emissions of some automotive gas turbine powerplants using both lean pre-vaporizing variable-geometry (PV-VG) and catalytic combustors with this standard. It is clear that both prototype combustors meet the standard by a significant margin. Note that the AGT100 and NoMac data report total HC emissions while the ULEV standard specifies non-methane hydrocarbon (NMHC) emissions. Therefore, the NMHC emissions of the turbines actually would be even lower than the values reported in Exhibit 3-1.

Conventional Four-Stroke Spark-Ignition Powerplants. In conventional automotive engines, the intermittent combustion process and short time available for mixing can lead to incomplete vaporization of the air-fuel mixture before ignition, resulting in stoichiometric burning of liquid fuel droplets and significant formation of NO_x. Tight clearances between the piston and cylinder wall can quench the flame, creating zones of much cooler temperatures that inhibit complete combustion, leading to formation of HC and CO. Lean-burn operation intended to reduce emissions of HC and CO can lead to even higher levels of NO_x. The difference between maximum and minimum combustion temperatures is generally much greater in piston engines than in gas turbines with lean PV-VG or catalytic combustors.

Conventional engines therefore require significant aftertreatment of exhaust to meet present emission standards. Vehicles powered by these engines will probably need even more complex and costly aftertreatment, as well as improved in-cylinder control of emissions to meet the ULEV standards. For example, it has been estimated that adding an electrically heated catalyst to an automobile could add approximately 18 kg of weight, reduce fuel economy by about 0.4 km/L, and add $822 to $1,045 to the price of the car.[1]

Exhibit 3-1
Projected Automotive Gas Turbine Emissions vs. California ULEV Standard

Engine or Emission Level Standard	HC (g/mi)	CO (g/mi)	NO$_x$ (g/mi)	Comments
AGT100 (diesel fuel) (methanol) (Lean PV-VG Combustor)	0.020 0.007 (total HC)	1.5 1.0	0.050 0.005	Projections based on combustor tests and 42.5 mpg fuel economy operating on diesel fuel.[2]
NoMac Genset (Catalytic Combustor)	0.033 (total HC)	0.0044	0.0061	Worst case projections (based on combustor tests) for intermittent operation on natural gas in a hybrid vehicle, specific range = 130 Wh/mi.[3]
Volvo Environmental Concept Car (ECC) (Lean PV-VG Combustor)	0.01 (not specified)	0.13	0.17	Laboratory testing results of actual vehicle using diesel fuel. Driving cycle not specified (FTP implied).[4]
California Ultra-Low Emissions Vehicle (ULEV)	0.040 0.055 (NMHC)	1.7 2.1	0.2 0.3	First 50,000 miles. Up to 100,000 miles.

Lean-burn operation also prevents the use of standard 3-way exhaust catalytic converters, which require a stoichiometric air-fuel ratio to operate effectively. All the major automakers are now performing research to develop catalytic converters that can function in lean exhaust, and they will probably succeed in doing so eventually. There are limited indications that zeolite-based catalysts may be effective in lean exhaust,[5] but these are preliminary laboratory results only.

Meeting future emissions standards through increasingly meticulous combustion control and/or exhaust aftertreatment will raise the cost and may reduce the performance of four-stroke spark-ignition (SI) engines, making gas turbines relatively more competitive. Despite these challenges, the automakers have a tremendous intellectual and material investment in four-stroke spark-ignition technology and will therefore probably choose to meet the ULEV and other emissions standards primarily through improved versions of these engines.

Two-Stroke Spark-Ignition Powerplants. Two-stroke SI engines have historically had severe emissions problems, which has been the primary consideration preventing their adoption for automobiles. Recent improvements in the technology, however, indicate that emissions performance of automotive two-strokes can be competitive with and possibly superior to that of four-stroke engines.

The high percentage of exhaust gas that is retained on each cycle by a two-stroke engine effectively provides internal exhaust gas recirculation (EGR). This EGR tends to reduce in-cylinder temperatures, thereby controlling NO_x formation at the source effectively enough that a NO_x-reducing catalyst is not required with some designs. Engines with air-assisted direct fuel injection and close-coupled oxidation catalysts have also achieved low HC, CO, and particulate emissions. Developmental engines using this technology have maintained emissions levels of 0.16 g/mi HC, 0.3 g/mi CO, and 0.24 g/mi NO_x for more than 80,000 kilometers. These emissions are comfortably below the Federal Tier I standards. Similar two-stroke engines have also been built that meet ULEV emissions standards at low mileage.[6]

Diesel Powerplants. With currently available technology, diesel emissions are more difficult to control than those of four-stroke engines due to their relatively high emissions of particulates and NO_x and their very lean combustion at part-load. Conventional three-way catalytic converters do not function properly at lean air-fuel ratios, and they can also be damaged by particulate-laden exhaust. Some of the technology that has enabled recent direct-injection lean-burn two-stroke engines to achieve high performance with low emissions may, however, be applicable to diesels.

Fuel Cells. Fuel cells are projected to have extremely low emissions, although competitive systems may be even farther from commercialization than gas turbines. The first demonstrations of practical fuel cell vehicles, using proton-exchange-membrane fuel cells, will not occur until the late 1990s.[7] Emissions from hydrogen-fueled fuel cells are zero (they produce pure water vapor). Projected emissions for vehicles powered by fuel cells using reformed methanol or similar fuels are on the order of 0.002 g/mile for HC, 0.001 g/mile for NO_x, and less than 2 parts per million for CO.[8]

3.1.1.2 *Alternative Fuels Capability*

Reducing petroleum consumption by the transportation sector through substitution of alternative fuels could lead to several benefits. These benefits include lowering tailpipe emissions with some powerplant/fuel combinations, reducing payments to foreign nations for petroleum imports, and reducing the economic and strategic vulnerability of the United States to disruptions in the petroleum supply.

The primary motivation for using alternative fuels in conventional vehicles is emissions reduction. It is therefore significant that gas turbines can achieve ultra-low emissions when burning gasoline.

Gas Turbines. The continuous combustion process of the gas turbine and the relatively long times it allows for mixing and vaporization of fuel makes it superior to any other viable automotive powerplant (except the heretofore unsuccessful Stirling engine) with regard to fuel flexibility. With continuous combustion, fuel properties that are critical to reciprocating engines, such as octane and cetane values, are irrelevant. Besides traditional liquid automotive fuels, gas turbines also run well on gaseous fuels such as compressed natural gas (CNG) and hydrogen, and have even been successfully demonstrated on dry powdered fuels such as micronized coal. The superior alternative fuels capability of gas turbines is clearly shown in Exhibit 3-2. While the other powerplants have a fair amount of fuel flexibility as well, none can be adapted as easily from one fuel to another as the gas turbine.

Exhibit 3-2
Alternative Fuels Capability of Selected Powerplants

	Biodiesel	CNG	Diesel	Ethanol	Gasoline	Jet Fuel	LNG	LPG	Methanol
GAS TURBINE	○	●	●	○	●	●	○	○	●
4-STROKE SPARK IGNITION		●		●	●		●	●	●
2-STROKE SPARK IGNITION		○		●	●		○	○	●
DIESEL	●	●	●	●			●	○	●
FUEL CELL		○		○			○	○	●

● = demonstrated in an automotive power plant
○ = possible fuel/power plant combination

It is possible that an individual gas turbine combustor could operate efficiently and with adequately low emissions on a number of fuels (although optimum efficiency and emissions might be achieved with only some of those fuels). Variable-geometry combustors, particularly if closed-loop feedback control of combustion is employed, might be programmable to automatically adjust to suit the particular fuel currently in use. The manufacturer of a gas turbine-powered vehicle could then provide an approved list of fuels for that vehicle. The operator of the vehicle would then be free to use whichever of the approved fuels is most convenient and economical at a particular time and location.

Piston Engines. Piston engines burn their fuels in an intermittent combustion process and therefore bave less fuel flexibility than gas turbines. Spark ignition engines require a fuel that will not ignite prematurely from the heat of compression. In contrast, compression ignition engines require a fuel that will ignite easily from the heat of compression, which can be particularly difficult to achieve in a cold engine.

Piston engines can be modified to operate on several fuels, but usually not more than one or at most two in a given vehicle. Performance of the vehicle is usually less than optimum on at least one of the fuel choices. For example, a limited number of "flexible fuel" vehicles powered by four-stroke spark ignition engines are currently in production, but these vehicles are generally only approved for various mixtures of just two fuels (e.g., gasoline and alcohols). Furthermore, the compression ratio of these engines must be lower than would be ideal for an alcohol-fueled engine because a higher compression ratio would cause detonation and engine damage when operated on gasoline, which has a lower equivalent octane rating.

Fuel Cells. Fuel cells consume hydrogen as their fuel. Until practical hydrogen storage technologies become available, hydrogen would need to be supplied to the vehicle in the form of methanol, or one of several other candidate fuels as shown in Exhibit 3-2, and thermally reformed on-board the vehicle into a feed gas rich in hydrogen and CO_2 in a separate component called a reformer. In the future, advanced fuel cells may be able to reform fuel internally, decreasing the weight and volume of the power system and increasing efficiency.

3.1.1.3 *Specific Power and Power Density*

Automotive powerplants must satisfy demanding weight and packaging requirements. Excessive powerplant weight or volume for a given power output compromises the performance and efficiency of the vehicle in which it is installed. Automakers will not produce vehicles with such powerplants because these vehicles would not be competitive.

Gas Turbines. Nearly all in-vehicle tests of gas turbines have been performed with all-metallic engines, which are heavier than turbines built with more advanced materials. Early gas turbines, however, were still close to contemporary conventional engines in specific power and power density.

Ceramic components will improve both specific power and power density. Their high-temperature strength allows the engine to be operated at a higher peak temperature, increasing power. Their lower density reduces engine weight. The combination of increased power and reduced weight leads to significantly improved specific power and power density compared to gas turbines with metallic hot sections.

Several advanced turbine designs also employ dynamic air bearings to support the rotating shaft. Air bearings can replace lubrication systems composed of oil, an oil pump, an oil filter, and an oil cooler, resulting in substantial weight and volume savings.

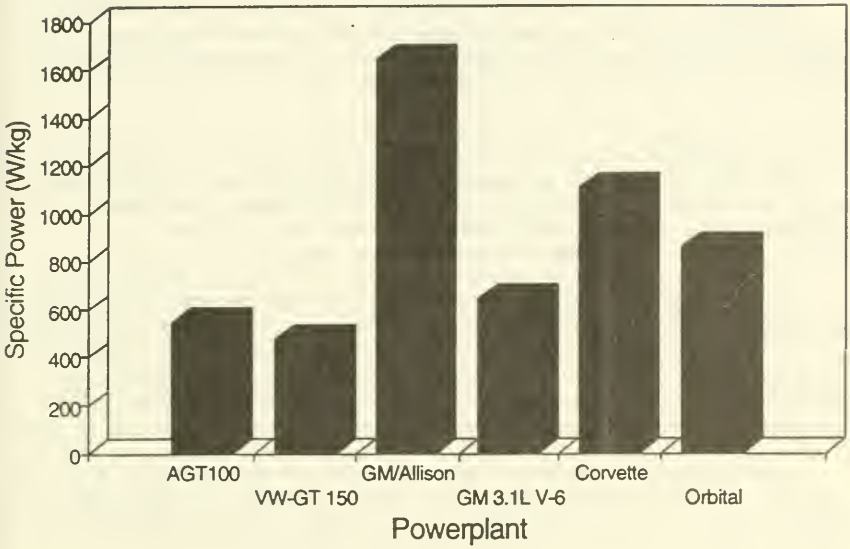
Conventional Powerplants. Conventional engines dictate expectations for the specific power and power density of alternative powerplants. Necessary supporting systems in these engines, however, reduce the overall specific power and power density of conventional engines. Conventional engines are burdened with the weight and volume of cooling systems, which include the radiator, hoses, water pump, and coolant (or the similarly heavy and bulky finning on air-cooled engines) in addition to the lubrication system components described above. Parasitic pumping losses in these systems can also consume several kilowatts of engine output at high engine speeds. Elimination of most or all of this weight, bulk, complexity, and parasitic power loss is a significant advantage of the gas turbine.

Exhibit 3-3 presents values for specific power (W/kg) for several fully-dressed engines (including required accessories and cooling systems, if any). Neither the AGT100 nor the VW-GT 150 represent the performance that could be achievable with a modern CGT. The AGT100 was designed primarily as a testbed for ceramic components, and the VW-GT 150 was a mostly-metal engine constrained to operate at lower peak temperatures. The GM/Allison engine is part of an ongoing advanced CGT development effort.[9] The engines labeled "GM 3.1L V-6" and "Corvette" are representative of typical and high-performance production four-stroke SI engines.[10,11] The Orbital engine is a developmental two-stroke engine that could see limited near-term production.[12]

Fuel Cells. Specific power and power density of present fuel cells is rather low, especially when the substantial weight and bulk of the reformer, load-leveling batteries, and other supporting equipment is considered. In the long term, however, monolithic solid oxide fuel cells may become available with specific power as high as 10 kW/kg.[13] This type of fuel cell operates at high temperatures and can reform its fuel internally. More advanced battery, ultracapacitor, or flywheel-based load-leveling technologies will also improve specific power and power density over the current state of the art.

Power Characteristics. At the beginning of the Advanced Gas Turbine (AGT) Program, General Motors conducted a computer simulation comparing the performance and fuel economy of a Pontiac Grand Am powered by a ceramic version of its AGT-100 gas turbine (called the "Reference Powertrain Design" or RPD) with a baseline Grand Am powered by a 2.5 L four-stroke spark-ignition engine. Actual vehicle and engine test data were used where available to improve the accuracy of the model. The simulated vehicles were "driven" over a mixed city/highway driving cycle. The simulation was reasonably thorough, accounting for transmission characteristics, drive line inertias and losses, tire characteristics, aerodynamic drag, accessory loads, and a cold-start fuel economy penalty.

Exhibit 3-3
Specific Power of Gas Turbines vs. Competing Powerplants



The RPD simulation predicted that the turbine powered Grand Am would be capable of accelerating from 0-97 km/h (60 mph) in 13.1 seconds, vs. the baseline vehicle's best performance of 13.5 seconds. The strong low-speed torque of the free-turbine AGT-100 engine compared to the SI engine is the primary reason for its better acceleration performance. Although the average time required by current (1991) four cylinder engine powered cars to complete this maneuver has dropped to a little over 12 seconds,[14] (the RPD study was performed over a decade ago), the competitive performance of the turbine with a contemporary SI engine is evident.

The simulation assumed that both vehicles began from idle. This is an important point because historically, turbine-powered vehicles have exhibited a short time lag between throttle application and the beginning of vehicle acceleration. This is due to the need to accelerate the gas generator section to high speed before the power turbine can begin to produce torque. Although the delay was noticeable in early turbine-powered vehicles, the reduced rotational inertia of ceramic components should significantly reduce this delay. Aerodynamic improvements to flow path components may help as well. Conventional vehicles have a slight delay also, due to initial slipping of the torque converter or clutch as the engine accelerates to a speed at which it can produce enough torque to accelerate the vehicle.

The torque characteristic of free-turbine engines gives them an even greater advantage in gradability over equivalent-horsepower SI engines. The simulation predicted that the baseline vehicle could maintain 89 km/h (55 mph) on a 7.9 percent grade while the turbine-powered vehicle could maintain the same speed on grades as steep as 10.9 percent.[15]

3.1.1.4 *Efficiency*

The thermal efficiency of a powerplant is reflected in the fuel economy of the vehicle in which it is installed. It is also reflected in the emissions of the engine. For a given combustion process, fewer toxic and greenhouse gas emissions will be generated if less fuel is burned to produce the required amount of power.

Thermodynamic Considerations. The efficiency of any combustion engine increases as the ratio of the maximum cycle temperature to the minimum (i.e., ambient) cycle temperature increases. This is the principal motivation for the development of high-temperature structural ceramic materials for gas turbines. Improvements in the performance of these materials could allow the turbine inlet temperature (TIT) of uncooled CGTs to be increased from the 1000°C typical of an uncooled metallic gas turbine to as high as 1370°C.

Brayton cycle efficiencies can be improved by increasing the pressure ratio of the cycle or by recovering waste heat from the exhaust with a regenerator or recuperator. Both methods increase the temperature of the air entering the combustion chamber, reducing the amount of fuel that must be added to heat the air to the maximum cycle temperature.

Pressure ratios above about 5 to 1 require multiple compressor and turbine stages. Multiple stage gas turbine powerplants have greater cost, complexity, size, and weight than simple-cycle powerplants.

Waste heat recovery is most beneficial for engines with high TITs and low pressure ratios. These engines have a large difference between the turbine exhaust and compressor outlet temperatures, increasing the amount of heat that can be recovered. As the pressure ratio increases, the temperature of the compressor outlet air approaches the turbine exhaust temperature. When these temperatures are equal, heat recovery becomes impossible. A turbine employing heat recovery can retain its high efficiency at the part-load conditions typical of automotive operation because the proportion of heat added from fuel combustion to the heat added from exhaust heat recovery decreases. Although gas turbine powerplants with heat recovery also have greater cost, complexity, size, and weight than simple-cycle powerplants, their improved efficiency at all operating conditions more than offsets these disadvantages. Virtually all automotive gas turbines designed or built to date have employed exhaust heat recovery, and it is expected that future designs will also do so.

Demonstrated Fuel Economy. Previous all-metal gas turbine engines that have been tested in vehicles have generally achieved highway fuel economy superior to conventional engines, but inferior city mileage, due to relatively higher idle and part-load fuel consumption. The all-metal third-generation Chrysler gas turbine achieved better fuel economy than a conventional car that accompanied it on a cross country trip in 1961.[16] The VW-GT 150 (rated at 100 kW) returned 6.55 km/L city and 10.7 km/L highway when installed in a typical 1980 model sedan.[17]

The larger all-metal automotive gas turbines that have been tested in trucks had thermal efficiencies of about 35 percent, comparable to the efficiency of a good spark-ignition engine but somewhat lower than a diesel. When scaled down to automotive size, a similar all-metal turbine could probably achieve about 32 to 33 percent efficiency.[18]

While they are often the only data available, peak thermal efficiency and steady-state fuel consumption are not all that relevant to an automotive powerplant. Most vehicles are operated over a mix of primarily part-load urban and highway driving. What is most important is the quantity of fuel consumed to drive the vehicle over a realistic driving cycle.

Projected Fuel Economy. The General Motors RPD computer simulation, described previously, predicted that the AGT-100 powered Pontiac Grand Am could achieve nearly 17.9 km/L (on gasoline) over the mixed city/highway driving cycle. The baseline 2.5 L Grand Am would be expected to achieve 13.1 km/L.[19] The improvement by the turbine is 35 percent, beating the AGT program goal of a 30 percent improvement in fuel economy relative to conventional engines. Peak thermal efficiency of advanced ceramic gas turbines has been projected to be about 42-46 percent.

Gas turbine powered hybrid vehicles could potentially achieve very impressive fuel economies. A computer study has conservatively projected that a small series hybrid vehicle with an intermittently-operated 24 kW all-metal gas turbine genset could achieve in excess of 31 km/L (on gasoline) at a steady 100 km/h.[20] A similar vehicle with a ceramic turbine could have even better fuel efficiency.

Because fuel cells produce electric current directly from the reaction of fuel and oxygen, without the inherently wasteful intermediate conversion of chemical energy to heat,[21] they can be substantially more efficient than any combustion engine. The projected efficiency of fuel cells is as high as 60 percent.[22] Because fuel cell powered vehicles will almost certainly employ inherently efficient hybrid powertrains, their potential efficiency gains over the conventional automobiles of today are very significant. Fuel cell powered vehicles are potentially more efficient than turbine powered hybrids.

3.1.2 Costs

Meeting the performance targets for the automotive gas turbine will not be sufficient to ensure that vehicles powered by these engines become a significant part of the overall fleet. A successful alternative powerplant must also have competitive initial and life-cycle costs.

Accurate projections of these costs are difficult to make, however, because ceramic gas turbines have never been mass-produced or operated in the "real-world." The original equipment manufacturers (OEM) have made some projections, but these are generally closely guarded proprietary information. Where reliable data was available, it was used. The following discussion, however, is based largely on anecdotal information and educated inference. It includes considerations that may be directly or indirectly considered as costs. Note that it only addresses costs arising after the prototype development stage. It does not specifically consider the substantial past or uncertain future research and development costs.

3.1.2.1 *Tooling, Startup, and Manufacturing Costs*

Ceramic gas turbines have unique components that must be fabricated from novel materials using processes that are not yet fully developed. The basic manufacturing processes for advanced ceramics are still being optimized. Technical and economic challenges of mass production of ceramic parts, particularly large and complex parts such as turbine rotors, variable-geometry combustors, and regenerator cores remain to be solved. Adaptation of high-volume production processes used in the alumina manufacturing industry might present a solution to the problems of cost-effective manufacturing of advanced ceramics.

The investment required to put a gas turbine engine into production could run to at least several hundred million dollars,[23] not including the cost of developing the powerplant and vehicle itself. Ceramic components cannot be manufactured using the existing tooling of the automotive industry. To mass produce automobiles powered by ceramic gas turbines, the ceramic manufacturing capacity would have to be increased by several orders of magnitude. There are two ways that this could happen. The OEMs could manufacture their own ceramic components, requiring them to build new factories or significantly expand existing ones. There is little doubt that they would do so if production volumes became large. Alternatively (and at least initially more likely), the OEMs could purchase these components from independent suppliers. The fledgling ceramics industry would then have to assume the primary risk of creating the expanded production facilities, and these costs would be passed on to the OEMs and ultimately, vehicle purchasers.

Tooling and startup costs of several hundred million dollars might seem prohibitive, but they are, in fact, within the capability of the automakers. The OEMs may spend as much as a billion dollars to develop a new family of conventional engines.[24] While it might be more expensive for the automakers to begin production of gas turbine powerplants than to maintain the status quo, these costs would not prevent production of CGT-powered vehicles if a demand for these vehicles exists.

Automakers and parts suppliers continually purchase new tooling to accommodate growing demand and to replace obsolete or worn-out equipment. Within 10 to 15 years, all current vehicle models and most engines and drivetrains will undergo at least one major change, and the manufacturing equipment will be written off.[25] A carefully planned gradual phase-in of CGT production by the automakers, taking advantage of this cycle of production tooling replacement, could offset much of the cost of introducing CGT-powered vehicles.

The higher cost of ceramic parts, relative to the cost of conventional engine parts made from alloys of steel and aluminum, is balanced by the lower number of parts in a gas turbine engine. The turbine's lack of a cooling system also lowers its parts count and cost. While precise numbers are not available to the public, General Motors' Manager of Turbine Programs estimated that the production costs of ceramic gas turbines could be competitive with V-6 engines of similar power if production volumes exceed 50,000 units per year.[26]

3.1.2.2 *Purchase Cost*

Based on the cost estimates above, it appears that CGT-powered vehicles would probably be sold at a slightly higher cost than similar vehicles powered by conventional engines. As time passes, the learning curve will rise and the startup costs will be amortized, which should tend to shrink the price differential and might eventually cause it to disappear.

3.1.2.3 *Reliability, Durability, Life Expectancy, and Scheduled Maintenance*

The extensive experience of the aviation industry and the limited experience of the automotive industry to date suggest that the automotive gas turbine could offer reliability and durability at least as good as, and probably better than, competing reciprocating engines. If automotive CGTs are ever offered for sale, it will mean that the ceramic (and other) components have achieved the necessary durability and reliability. In any case, the engine core of any automotive engine, whether Brayton, Otto, or Diesel cycle, would probably be highly reliable and durable. Most vehicles on the road today go their entire lives without unscheduled maintenance on the engine core, and gas turbines should (to succeed they must) exhibit the same level of reliability.

As they do now in vehicles powered by conventional engines, maintenance problems in CGT powered vehicles are less likely to arise from the engine core as they are from the systems and accessories. Examples of such systems in conventional engines include the increasingly sophisticated emission control systems and the cooling system. Because the gas turbine can meet the emissions standards without aftertreatment devices, these potential sources of failures would be eliminated. Gas turbines also do not have primary cooling systems, and probably can be designed so that they will not need oil cooling systems, thereby eliminating additional failure mechanisms. The electronic controls necessary for turbines probably would be similar in complexity to those used in modern conventional engines, and possibly less complex, and would therefore be expected to have similar reliability.

At the outset of the AGT program, 3,500 hours (equivalent to 160,000 km of average driving) was established as a development goal for the life expectancy of the CGT engines.

Reliability and durability are both desirable attributes for an automotive powerplant, but the distinction between them is important. A durable powerplant lasts a long time, despite heavy usage. A reliable powerplant can be counted on to perform as expected. The subtle difference is that durability can sometimes be sacrificed in an automotive powerplant, but consumers demand very high reliability. Examples of conventional automobile components that are highly reliable but only moderately durable, and must therefore be replaced periodically, include oil, filters, belts, and spark plugs.

There would probably be few scheduled maintenance requirements for automotive gas turbines. Engine oil changes, if required at all, would be much less frequent than for conventional piston engines. Regenerator cores will be exposed to continuous cycling of temperature and flow direction, which will help to keep them clean and free of fouling.

Regenerator seals have been identified as a component that could limit the reliability of CGTs, however seals with 10,000 hour durability at 1,038°C have been demonstrated in the laboratory.[27] Even if such results are difficult to achieve at reasonable cost in practice, this is an example of a component where durability might possibly be sacrificed, provided that high reliability can be guaranteed. Consumers might accept a seal that reliably lasts for at least several hundred hours, provided that it could be easily and inexpensively replaced. It should be possible to design an automotive turbine that allows fairly simple access to the regenerator seals. This approach could be feasible if the difficulty and cost of seal replacement was comparable to replacement of the oil and filter in a conventional engine.

Fixed-boundary recuperators (currently fabricated from metals) are successfully employed in some production gas turbines. Although a mass-producible ceramic recuperator has not yet been developed, it would eliminate all moving parts in the heat exchanger system including the high-temperature dynamic seals. With no moving parts, a fixed-boundary recuperator could be expected to be highly reliable (although probably slightly less effective than a rotary regenerator).

3.1.2.4 *Operating Costs*

The primary contributor to operating costs is the cost of fuel and oil. Because of the CGT's high fuel efficiency, ability to use inexpensive fuels, and infrequent oil changes, these costs could be lower than the corresponding costs for conventional engines, possibly substantially lower.

The other major contributors to operating costs are the costs for scheduled and unscheduled maintenance. As stated above, these costs will probably be competitive with the corresponding costs for other powerplants.

Depreciation can also be considered an operating cost, but it is less significant than the direct costs. With the limited information available, it is difficult to estimate the relative depreciation rate of the CGT compared to other engines.

Overall, considering the combined effects of purchase, maintenance, and operating costs, it is likely that the life cycle costs of a CGT-powered vehicle would be competitive with or possibly even lower than those for comparable conventional vehicles.

3.1.2.5 *Infrastructure Needs*

No special requirements for CGT-powered vehicles are foreseen for fueling facilities, roadway changes, or operational requirements. Alternative fuels, if used, would require some changes at service stations, but this is true regardless of the powerplant.

3.1.2.6 *Service/Maintenance Industry Requirements*

As with any new powerplant, service technicians will need to acquire additional knowledge, tools, and diagnostic equipment. The experience of the airline industry illustrates that such changes are feasible, if there is a sufficient incentive.

For CGTs, like conventional engines, failures of the engine core itself would be rare. The typical corner garage is incapable of performing an engine overhaul or repairing a serious failure deep within a conventional engine, and the same will be true for CGTs.

The accessories installed on a CGT will most likely be similar to those installed in current vehicles. Service personnel should not have any unusual problems maintaining or troubleshooting these systems.

3.1.2.7 *Safety Considerations*

The gas turbine has proven itself to be safer than piston engines in aviation, and the same should be possible in vehicles. Safety can and will be designed into any automotive gas turbine powerplant. Turbine-powered vehicles, therefore, should not lead to significantly increased liability exposure for manufacturers.

In the unlikely event of a rotor burst, persons in and near the vehicle would have to be protected from the possibility of escaping debris. Containment should be manageable; the housings of the AGT engines successfully contained several rotor failures during testing.

3.2 CERAMIC MATERIALS TECHNOLOGY

Simple uncooled turbines made of traditional (and moderately expensive) nickel-based superalloys are limited to peak TITs of about 1000°C. Experimental automotive turbines have shown that a metal engine constrained to operate at these temperatures will, at best, just match the fuel economy of a good spark-ignition engine over a typical mixed driving cycle.[28,29] Equivalent efficiency, of course, is not enough to justify production of a new powerplant. Researchers have concluded that the gas turbine must demonstrate a 30 percent fuel economy advantage over comparable spark-ignition engines[30] to become a viable automotive powerplant. This would require that the engine be operated at peak temperatures of 1288-1370°C.[31] (Turbine-powered hybrid vehicles may, however, offer fuel economy competitive with conventional vehicles, even at lower peak operating temperatures).

No presently known, cost-effective material can withstand 3,500 hours of exposure to the extreme thermal and mechanical stresses that would be experienced in a gas turbine operating at peak temperatures up to 1370°C. Advanced ceramics currently appear to have the most potential among candidate materials, although it is possible that an even more promising class of materials might appear in the future. Several advanced ceramics developed by U.S. companies are listed in Exhibit 3-4.

Exhibit 3-4
Advanced Ceramics Under Development by U.S. Companies

NAME	DESCRIPTION	APPLICATIONS	MANUFACTURER
(unnamed)	Lithium Aluminosilicate	Regenerator Disks	Corning
(unnamed)	Sodium-Zirconium-Phosphate	Regenerator Disks	Corning
AS800	In-Situ Toughened Si_3N_4	Rotors	AlliedSignal Ceramic Components
Cerachrome	Al_2O_3-SiO_2-Cr_2O_3	Thermal Insulation	Schuller International
Cordierite	Magnesium Aluminosilicate	Regenerator Disks	Corning
GN10	Monolithic Si_3N_4	Rotors	AlliedSignal Ceramic Components
Hexoloy SX	Monolithic SiC	Rotors, Vanes, Ducts	Carborundum
NCX-5102	Monolithic Si_3N_4	Rotors, Vanes, Ducts	Norton/TRW Ceramics
NT154	Monolithic Si_3N_4	Rotors, Vanes, Ducts	Norton/TRW Ceramics
NT164	Monolithic Si_3N_4	Rotors, Vanes, Ducts	Norton/TRW Ceramics
NT230	Monolithic Siliconized SiC	Scrolls	Norton/TRW Ceramics
SRS-201	In-Situ Toughened SiAlON	Rotors	Ceramics Process Systems

The following discussion of some candidate materials for advanced gas turbines is intended to illustrate the challenges and successes in their development. The data are the most recent that could be obtained, but given the rate of progress to date, there is a strong likelihood that the performance of these materials has improved further. Some property data for some materials was unavailable or based on inconsistent testing procedures, making direct comparisons with other materials impossible. For these reasons, the reader should consider this discussion only as an illustration of progress to date and remaining challenges, not as a recommendation of any particular supplier, material, or fabrication process.

3.2.1 Challenges to Development of Advanced Ceramics

Building gas turbines with ceramic hot-section components has been a goal for decades.[32] Only recently have ceramic materials approached the performance necessary to build a viable engine. The most severe performance problem has been the brittleness of ceramics. Unlike ductile metal parts, brittle ceramic parts are unable to relieve stress concentrations by experiencing localized plastic deformations and are therefore very sensitive to manufacturing flaws. A ceramic part can fail due to a stress concentration caused by an internal pore (casting or molding flaw), a surface scratch (forming or machining flaw), or an impurity (powder preparation or handling flaw), even though the intrinsic strength of the material is satisfactory. In addition to improving the strength and toughness of the ceramic material itself, a great deal of effort has been applied to reducing the flaw population in finished parts.

There are many important properties that ceramics researchers must optimize. Some of the most important are:

- Strength - A measure of the maximum steady load that a material can withstand without failure
- Fracture Toughness - A measure of a material's ability to withstand an impact without failure
- Fatigue Life - The number of application and removal cycles of a moderate load that a material can endure without failure
- Weibull Modulus[*] - A statistical measure of the consistency of a material's or part's strength.

A material must meet minimum requirements of these and other important properties, both at room and operational temperatures, or it will not provide adequate performance or reliability in an engine. Exhibit 3-5 describes values of some of the most significant ATTAP goals (fo Si_3N_4 rotors). Note that the material properties required are often interrelated and should be defined as a set. For example, the thermal stresses in CGT components operated at high temperatures are often significantly greater than the mechanical stresses, particularly during transients such as starting and acceleration. Thermal stresses result from uneven expansion due to temperature gradients within the component. The stresses are therefore affected by the thermal expansion and thermal conductivity characteristics of the material (as well as the rate of gas stream temperature change and component geometry).

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[*] The Weibull modulus is a measure of the statistical consistency of material properties from one sample to another. Weibull statistics are particularly well suited for describing phenomena that can be represented by a "weakest link" model, such as the strength of ceramics. Unless otherwise specified, the Weibull modulus usually is calculated from the distribution of ultimate strength measurements of a sample of identical parts made from a material. A low Weibull modulus indicates that the material properties are relatively variable, making it difficult to predict the performance of an untested part. A material with a high Weibull modulus allows a designer to have more confidence in the performance of a part made from that material. Because of their ductility and consequent ability to reduce stress concentrations, metals have very predictable properties that are reflected in their high Weibull moduli, approaching infinity.

Exhibit 3-5
Selected ATTAP Goals

Material Property	**Approximate Minimum Performance Required for Production**
Strength at Room Temperature	689 MPa
Strength at 1370°C	586 MPa
Weibull Modulus	20
Fracture Toughness	10 MPa-$m^{1/2}$

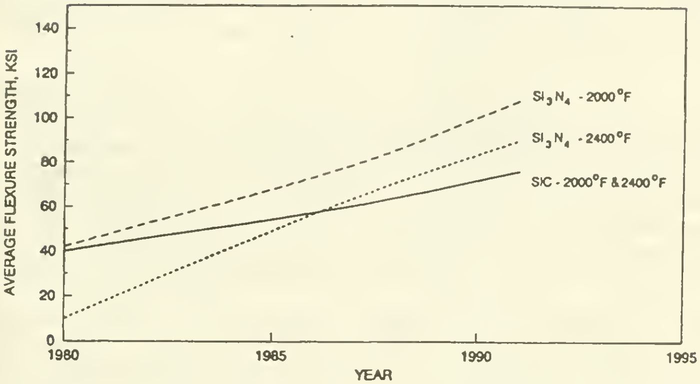
3.2.2 Improvements in Ceramics

The improvement in the mechanical properties of these materials over the course of the AGT and Advanced Turbine Technology Applications (ATTAP) programs is remarkable. Exhibits 3-6 through 3-9 show the improvements in selected mechanical properties of some ceramic materials developed under the AGT and ATTAP programs.

Exhibit 3-6 shows a steady increase in the strength of representative Si_3N_4 and SiC ceramic materials, more than doubling maximum achievable performance levels between 1980 and 1992. The strength of Si_3N_4 at 1316°C (2400°F) increased by more than a factor of eight during this period. No leveling-off of the strength curves is evident, suggesting that continued improvements can reasonably be expected.

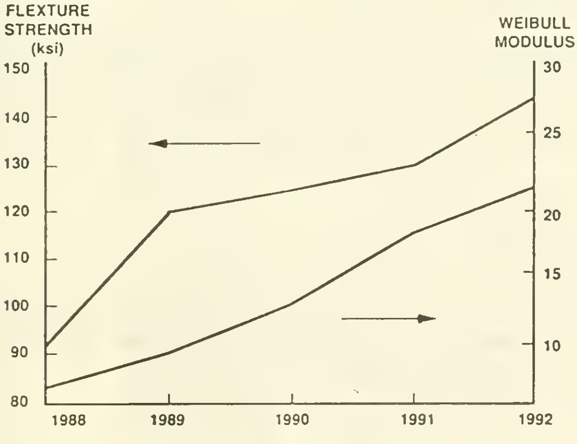
Exhibit 3-7 shows the improvement in the room temperature flexure strength and Weibull modulus of GN10 between 1988 and 1992. Both properties have shown consistently significant improvements from year to year and now exceed ATTAP goals for these properties.

Exhibit 3-6
Improvement in Average Flexure Strength of Si_3N_4 and SiC



Source: Composite of Data from AlliedSignal and Allison

Exhibit 3-7
Improvement in Flexure Strength and Weibull Modulus of GN10 Si_3N_4



Source: AlliedSignal Ceramic Components

Exhibit 3-8 illustrates the improvement in flexure strength at room temperature and 1370°C of various Norton/TRW silicon nitrides. Again, the doubling of strength between 1980 and 1992 is clearly evident. This graph also shows the quantum improvement in fatigue life (at 100 MPa and 1370°C) of these materials, from a few minutes in 1980 to about 7,000 hours (double the engine life goal of 3,500 hours) in 1991.

Exhibit 3-9 compares several mechanical properties of GN10 and AS800. The AS800 is toughened by promoting the growth of elongated grains of second-phase Si_3N_4 within the material during sintering. These randomly-oriented elongated grains toughen the material, essentially creating a composite material. The properties shown in the graph are impressive, particularly the high fracture toughness. What is most intriguing about this material is that its strength is controlled primarily by microstructural features developed during heat treatment, and is less susceptible to initial processing flaws. This behavior improves the confidence a designer can have in predicting the strength of this material in a mass-production situation.[33]

Exhibit 3-10 compares the flexure strength of several state-of-the-art ceramic materials at room temperature and 1204°C with ATTAP goals. The Weibull moduli of these materials are also compared to the program goal. It is immediately apparent that all of the selected materials exceed ATTAP goals for flexure strength, some by substantial margins. Note that some of these materials, particularly the Japanese Si_3N_4, are significantly stronger than the program goals. The high strength of these materials might compensate for the uncertainty in their strength indicated by the below-goal Weibull modulus, allowing designers to use these materials with confidence to build a CGT.

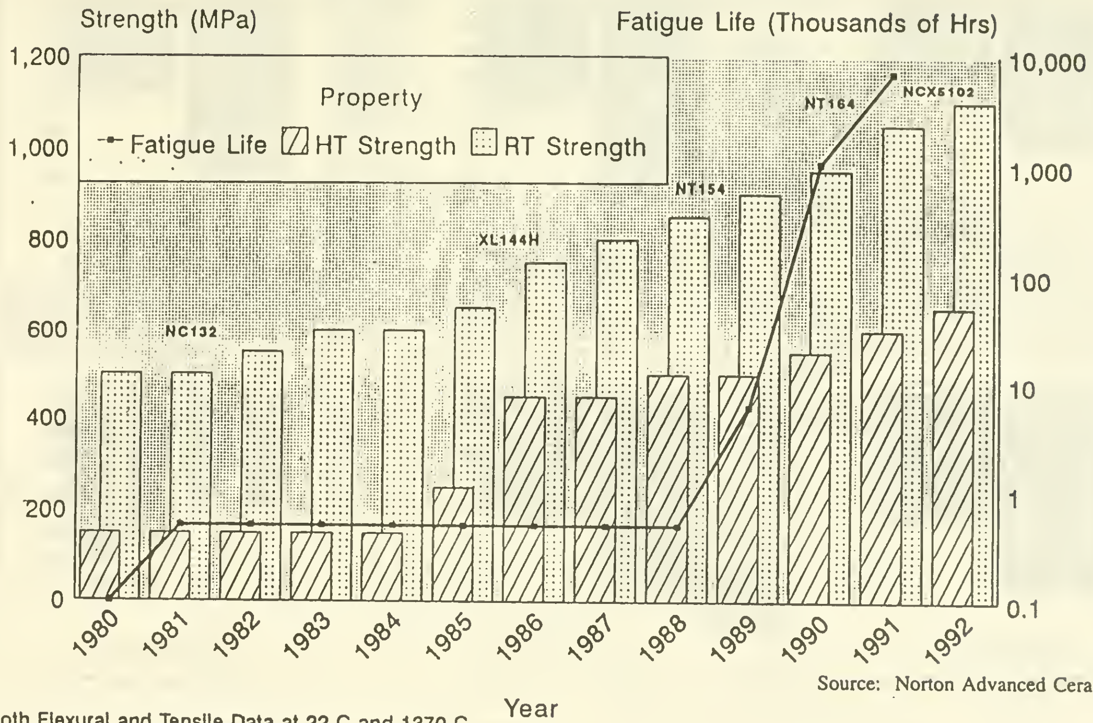
3.2.3 Cost-Effective Ceramic Manufacturing

Now that the mechanical properties of advanced ceramics are approaching and in many cases exceeding ATTAP goals, the R&D emphasis has shifted to developing cost-effective manufacturing processes. There are several contributors to the cost of a finished ceramic part that are significantly different from the processes involved in producing parts from traditional materials. These include the costs of:

- Ceramic starting powders
- "Green" part forming
- Densification
- Machining to final shape.

Reductions in the cost and processing time for any of these steps will reduce the cost and processing time for the entire part. Poor yields, due to out-of-tolerance or broken parts, also have a pronounced effect on the cost of the parts that are delivered.

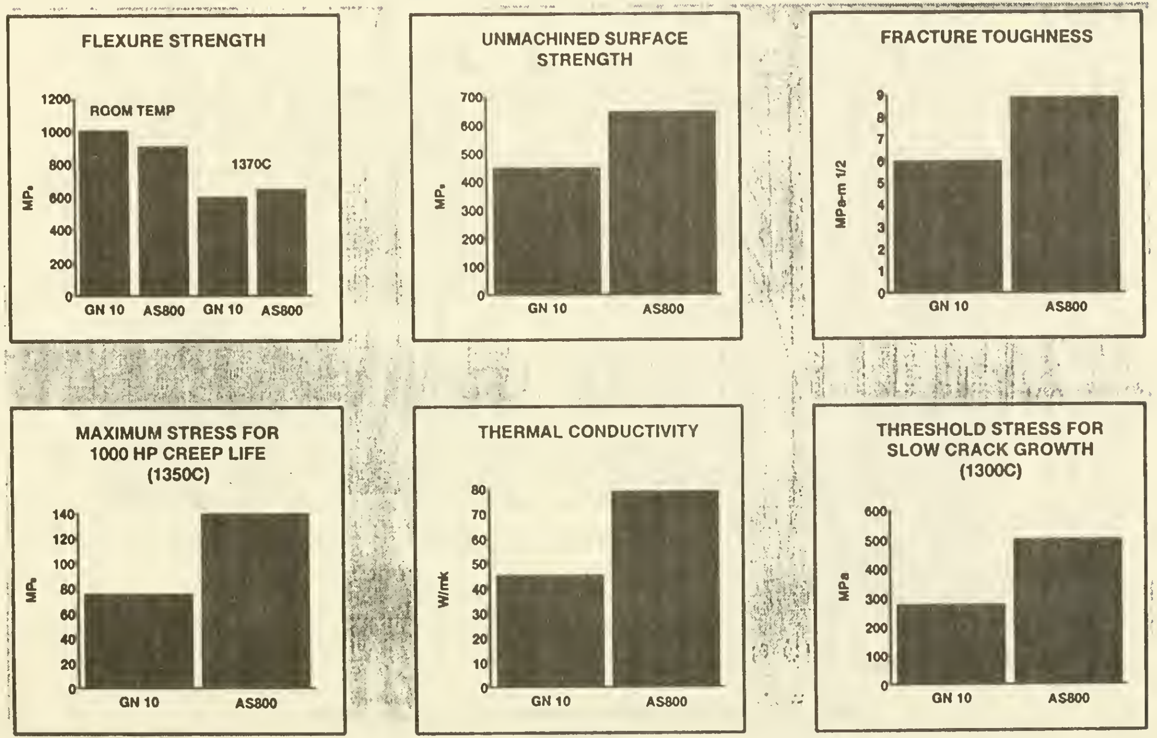
Exhibit 3-8
Improvement in Mechanical Properties of Norton/TRW Si_3N_4



Source: Norton Advanced Ceramics

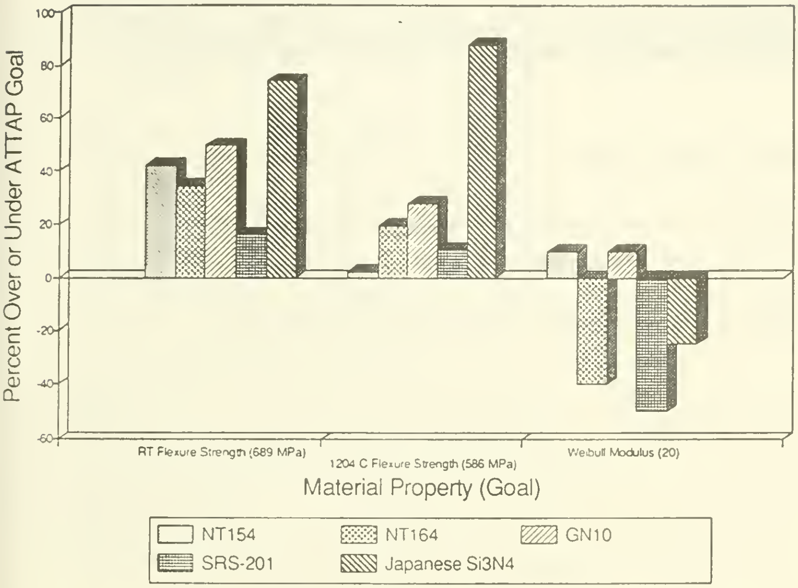
Both Flexural and Tensile Data at 22 C and 1370 C.
Static Fatigue - 100 MPa at 1370 C.

Exhibit 3-9
Comparison of Mechanical Properties of GN10 and In-Situ Reinforced AS800



Source: AlliedSignal Ceramic Components

Exhibit 3-10
Material Properties of Selected Ceramics vs. ATTAP Goals



Researchers are pursuing several avenues for cost reduction including:

- Reducing starting powder cost
- Improving forming techniques to increase yields and improve dimensional accuracy (near-net-shape fabrication) so less machining is required
- Machining of components before densification, while in the softer green state
- Reducing the time and energy required for densification

- Reducing the time required for machining densified parts and reducing breakage of parts during machining.

While additional cost reductions must be found, progress to date has been encouraging. Ceramic parts that once cost tens of thousands of dollars to produce in laboratory quantities can now be produced for hundreds of dollars in small developmental quantities.[34]

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4.0 BARRIERS TO COMMERCIALIZATION OF AUTOMOTIVE GAS TURBINES

Based on the previous discussion, the gas turbine appears to be a potentially desirable automotive powerplant, particularly if the hot-section components are made from advanced ceramics. There are, however, some significant barriers that must be overcome before the automakers will build vehicles powered by gas turbines. These barriers are discussed below and summarized in table form in Appendix B.

4.1 TECHNOLOGY BARRIER

The most critical intrinsic barrier to the success of the automotive gas turbine is the current lack of cost-effective materials that can survive for at least 3,500 hours at turbine inlet temperatures as high as 1370°C. Without such materials, the gas turbine cannot achieve the efficiency or specific power advantages necessary to displace established automotive powerplants.

The mechanical properties of several ceramic materials have been improved to the point where they can meet and in some cases exceed most of the Advanced Turbine Technology Applications Program (ATTAP) goals. However, cost-effective materials that can meet or exceed all of the ATTAP goals do not currently exist. It is critical to the commercialization of automotive gas turbines, at least as prime movers, that both performance and cost goals be met for ceramic components. The fact that ceramic turbocharger rotors (which experience significantly lower temperatures and stresses) have been in production for a number of years suggests that the ceramic gas turbine (CGT) could eventually be economically viable.

The challenges of developing aerodynamically efficient small turbomachinery, durable dynamic seals, reliable variable-geometry combustors, and high-temperature lubricants are not as great, but still cannot be overlooked. Turbines are also more size-sensitive than piston engines; it is more difficult to achieve high efficiency with a small turbine than with a large one.

The most significant extrinsic impediment to the development of the gas turbine as an automotive powerplant is the possibility that other approaches to reducing fuel consumption and emissions may provide a greater return on investment. Four-stroke spark ignition (SI) engines have been evolving for more than 100 years and have reached a high level of performance. Within the past two decades, fuel economy has improved dramatically[1] (vehicle improvements are partially responsible and some of the efficiency gains would carry over to vehicles with alternative powerplants), and exhaust emissions have been reduced by more than an order of magnitude.[2] Although it seems that investing in further refinement of this engine will be subject to diminishing returns, accompanied by increasing cost and complexity, historical trends indicate that there is still the possibility of significant improvement.

Two-stroke SI engines may be developed that have fuel economy and emissions competitive or even superior to four-strokes in a smaller, lighter, less-expensive package. Fuel cells may entail a greater development risk than CGTs, but could provide greater benefits in terms of reduced fuel consumption and emissions than are possible with the gas turbine, or any combustion-based engine for that matter.[3] Efficient hybrid powertrains can be built around virtually any powerplant and will achieve significantly improved fuel economy and emissions compared to similar powerplants in a prime mover configuration.

4.2 INSTITUTIONAL INERTIA BARRIER

The world's automakers have many billions of dollars invested in piston engine technology. Much of their manufacturing equipment would have to be supplemented or replaced to produce an engine as radically different as the CGT. It should be reiterated, however, that a carefully-executed phase-in of CGT production, timed to coincide with normal equipment replacement cycles, could offset much of the tooling-up expense.

Besides the worth of the automakers' equipment, there is the inestimable value of the experience of their personnel in areas such as theory, design, manufacturing, new vehicle sales, and maintenance. A substantial amount of this experience would be applicable to the CGT, but much would have to be learned anew. The original equipment manufacturers (OEM) will not abandon this investment in equipment and experience without compelling reasons for doing so. The CGT would have to offer clear advantages over both four-stroke SI engines and other alternative powerplants to justify the disruption its adoption would create.

4.3 MARKETABILITY BARRIER

The OEMs would not only have to learn how to produce vehicles powered by high-performance CGTs at competitive costs, they would have to be able to sell significant numbers of these vehicles. History is rife with examples of well-designed cars that experienced disappointing sales. Consumers shopping for a new car are justifiably wary of totally new technologies. They might want to see proof of the advertised benefits and reliability of the CGT before spending their own money. This is also true for other alternative technologies including two-stroke SI engines, fuel cells, and hybrids.

On the other hand, some consumers are drawn to radically new vehicles primarily for their uniqueness. People who have had the opportunity to drive turbine-powered cars and trucks have responded enthusiastically to the experience, with many expressing a desire to own a turbine-powered vehicle. The attractions included strong torque, smoothness, quietness, and the novelty of new technology.[4,5,6]

Manufacturers will also face uncertainties related to marketing CGT-powered vehicles. Without the benefit of field experience with CGTs, it will be difficult to estimate warranty costs. A mistake here could be extremely costly. Preliminary fleet tests and demonstrations could help the OEMs obtain this information and would undoubtedly be in the plans of any manufacturer contemplating production of a CGT-powered vehicle. Demonstrations could also create consumer interest in turbine-powered vehicles even before these vehicles become available. The battle-proven success of the U.S. Army's turbine-powered M-1 Abrams main battle tanks have demonstrated the potential reliability of gas turbine vehicles.[7]

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APPENDIX A

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APPENDIX B

COMPARISON OF AUTOMOTIVE POWERPLANTS

APPENDIX B

COMPARISON OF AUTOMOTIVE POWERPLANTS

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Criteria	Gas Turbine	4-Stroke Spark Ignition (Baseline)	2-Stroke Spark Ignition	Diesel	Fuel Cell
PERFORMANCE:					
Emissions 50,000 mile standards (g/mile) 1994 Federal Tier 1. NMHC 0.25 CO 3.4 NO_x 0.4 PM 0.08 1998 California ULEV NMHC: 0.04 CO: 1.7 NO_x: 0.2	Can meet California ULEV without exhaust aftertreatment if prevaporizing variable-geometry or catalytic combustor is used [1] Using these technologies, turbines can produce just 10-30% of 4-stroke SI emissions levels [1]	Requires aftertreatment of exhaust combined with careful design of combustion chambers, intakes, exhausts, and fuels to meet present emissions standards. Meeting ULEV standards will require additional investment in R&D. ULEV emissions controls may add up to 30 kg of weight and reduce fuel economy by up to 4%. [1]	Intrinsic exhaust gas recirculation (EGR) compared to 4-stroke reduces combustion temperatures and controls NO_x formation in the cylinder (a NO_x-reduction catalyst may not be required, at least in smaller vehicles). Compliance with Tier 1 for over 80,000 km (0.16; 0.3; 0.24 g/mi for HC, CO, and NO_x) has been demonstrated. Compliance with ULEV (0.025; 0.08; 0.15) has also been demonstrated by low mileage engines [4]	Diesels are lean-burn engines with relatively cool part-load exhaust temperatures and much excess O_2 in the exhaust, precluding the use of 3-way catalysts. In addition to developing aftertreatment systems, technologies to reduce formation of pollutants in the combustion chamber[5] and/or the use of methanol fuel[6] may also be required Recently developed LD diesels meet current European standards[7,8] but diesels will probably have difficulty meeting increasingly stringent U.S. standards	When hydrogen-fueled, only pure water vapor is emitted. When fueled by reformed methanol or similar fuels, regulated emissions are virtualy zero and CO_2 emissions are lower than those from heat engines for the same power output (due to greater fuel economy of fuel cells).
Alternative Fuel Capability BD=biodiesel, CNG=compressed natural gas, D=diesel, E=ethanol and blends, G=gasoline, H=hydrogen, J=jet fuel (kerosene), LNG=liquified natural gas, LPG=liquified petroleum gas (propane), M=methanol and blends	Continuous combustion gives the gas turbine greater overall and single-vehicle fuel-flexibility than any powerplant in this table. Almost any liquid or gaseous fuel could be used. Actual fuel choices would be based on emissions performance and fuel system compatibility. Demonstrated: CNG, D, G, J, M Likely Others: BD, E, H, LNG, LPG	Requires high "octane" fuel for preignition resistance, can use liquid or gaseous fuels, but a given vehicle probably cannot use more than 2 Demonstrated: CNG, E, G, H, LNG, LPG, M Likely Others: ?	Capability similar to 4-stroke Demonstrated: E, G, M Likely Others: CNG, H, LNG, LPG	Diesel engines require high "cetane" fuels and/or ignition assist (could be fuel additive, hardware, or both) for reliable compression ignition, especially when cold Demonstrated: BD, CNG, D, E, LNG, M Likely Others: LPG	Fuel cells consume hydrogen, which can either be stored directly, or chemically bound in a more complex fuel and thermally reformed into hydrogen and CO_2 Demonstrated: H, M Likely Others: CNG, E, LNG, LPG

Criteria	Gas Turbine	4-Stroke Spark Ignition (Baseline)	2-Stroke Spark Ignition	Diesel	Fuel Cell
Specific Power (Fully-dressed engines)	Allison AGT100 (ceramic): 547 W/kg[9] Volkswagen GT 150 (metal). 476 W/kg[10] Developmental GM/Allison design estimated at about 1,640 W/kg, exact number is proprietary. Weight of turbine vehicle estimated to be 136 kg less than comparable 4-cylinder [11]	General Motors 3.1L V-6 (Corsica, etc.): 645 W/kg.[12] High-performance mass-produced engine (1990 Corvette). 1100 W/kg [13]	Orbital 1.2L 3 cylinder: 853 W/kg.[14] Two-stroke engines have 40% better specific power than equivalent 4-stroke SI engines.[15] A 2-stroke powered vehicle would weigh an estimated 45-90 kg less than a comparable 4-stroke powered vehicle.[16]	1994 production HD engines: 174-263 W/kg[17] (includes weight of cooling systems)	Presently low, potentially up to 10,000 W/kg for monolithic solid oxide fuel cells[18] (does not include necessary electrical load-leveling system or drivetrain, although overall specific power should still be high).
Power Density (Direct comparisons may be misleading because piston engine data generally does not indicate whether reported volume includes cooling system and accessories)	VW-GT 150 364 W/L[19] Developmental GM/Allison design estimated at about 500 W/L including accessories, exact value is proprietary.[20]	Average of five 1990 Sedans with "modern" engine designs: 573 W/L High-performance mass-produced engine (1990 Corvette): 878 W/L[21]	Packaging volume is reduced by up to 70% compared to an equivalent 4-stroke[22] (this figure relates only to the engine core itself)	Lower than competitors	Presently low, potentially very high, especially for monolithic solid oxide fuel cells (load-leveling and powertrain will reduce power density, but it will still be high).
Efficiency	AGT100 projected 35% improvement (based on fuel energy content) in composite fuel economy (20.5 km/L on diesel fuel) over comparable contemporary SI engine[23]	34-35% thermal efficiency at design point. This is about 243 g/kWh (0.4 lb/bhp-hr) based on gasoline. Projections for "practically achievable" fuel economy levels for midsize cars ("higher confidence-lower confidence")[24]: 1996: 11.5 km/L 2001: 12.3-13.2 km/L 2006: 13.6-14.9 km/L	Up to 30% improvement in fuel consumption compared to vehicle powered by equivalent 4-stroke SI engine, when 2-stroke SI engine weight savings are propagated through vehicle [25]	Volkswagen 1.9L direct-injection turbo diesel 41.8% peak thermal efficiency [26] Current HD engines: 40-46% thermal efficiency 182-213 g/kWh (0.3-0.35 lb/bhp-hr) at design point. LE-55 (LHR) goal: 55% thermal efficiency (152 g/kWh or 0.25 lb/bhp hr)[27]	Up to 60% fuel energy to electrical power conversion efficiency predicted [28]

Criteria	Gas Turbine	4-Stroke Spark Ignition (Baseline)	2-Stroke Spark Ignition	Diesel	Fuel Cell
COSTS:					
Tooling/Startup Costs (These costs will be borne by the OEMs but will be amortized in the selling price of the vehicles produced)	Potentially hundreds of millions of dollars, but could be significantly reduced by strategically planned replacement of old equipment with CGT production capability	Baseline	Similar to producing a new family of emissions-compliant 4-stroke SI engines.	Similar to producing a new family of emissions-compliant 4-stroke SI engines.	**Unknown at this time.**
Purchase Cost	Some initial cost premium likely in order to absorb startup costs. Production cost estimated to be competitive with V-6 powered vehicle if annual production volumes reach 50,000 or more (higher per-part cost than SI engine, but for fewer parts)[11]	Baseline	Powerplant cost may be reduced by up to 20% compared to equivalent 4-stroke SI engine.[10]	Within 10% of 4-stroke SI cost at present, but emissions-compliant LD diesels could be more expensive.	**Unknown at this time.**
Scheduled Maintenance Requirements	Fuel filter, air filter (if barrier-type). Oil and filter changes, if required at all, would be much less frequent than for SI and diesel.[11] Possible need for periodic cleaning of recuperator cores or regenerator seal replacement	Periodic replacement of oil and oil filter, air filter, spark plugs; possible need for periodic replacement of timing belt and valve adjustment	Similar to 4-stroke SI.	Relatively frequent replacement of oil and oil filter; replacement of air and fuel filters; possible need for periodic timing belt replacement or valve adjustment	**Unknown at this time.**
Reliability, Durability, Life (Years/Miles)	High in aviation (3,000-5,000 hours between overhauls), likely to be similar in automobiles (ATTAP life goal is 3,500 hours, assumed to be equivalent to 100,000 miles of driving)	Baseline. Light-duty SI powered vehicles typically last for 100,000 to 150,000 miles	Probably similar to 4-stroke SI engines	Probably the most durable automotive powerplant (partly due to low specific power). LD diesels often last up to twice as long as similar SI engines. (HD diesels often go 300,000 to 500,000 miles between overhauls.)	**Unknown at this time, but very long lives may be possible, especially with solid-state types**
Operating Costs	Probably lower than SI operating costs due to high efficiency and minimal required maintenance.	Baseline.	Probably comparable to or slightly lower than 4-stroke SI-powered vehicle.	Somewhat lower than SI powered vehicle.	**Unknown at this time, but probably lower than for heat engines.**

Criteria	Gas Turbine	4-Stroke Spark Ignition (Baseline)	2-Stroke Spark Ignition	Diesel	Fuel Cell
Infrastructure Needs (Special fueling facilities, roadway changes, operational requirements or limitations)	Little to none. None of these powerplants will require changes to roads or parking facilities. Acceptance of LD diesels is hampered by a limited refueling infrastructure. Alternative fuels, if used in one or more of these powerplants, may require new fueling facilities.				
Service Industry Requirements (Servicing, maintenance)	Somewhat greater supplemental training for mechanics (compared to baseline 4-stroke SI) and some new diagnostic equipment.	Mechanics may require some supplemental training to diagnose and service future emission-controlled engines	Minor supplemental training for mechanics beyond that required for 4-stroke SI	Mechanics may require some supplemental training to diagnose and service future emission-controlled engines	Unknown at this time.
Safety	All engines expected to be similar with regard to safety-related liabilities				
BARRIERS TO COMMERCIALIZATION:					
Technology Barrier	Performance of ceramic materials has improved dramatically, yet cost-effective manufacturing processes for ceramics do not presently exist and must be developed. Ceramic component life at real-world operating conditions remains to be demonstrated Aerodynamics and combustor design require additional R&D, but are not as critical as cost-effective ceramics. Lower-technology approaches may succeed in niche markets (e g., hybrid vehicles)	Moderately expensive and complex technology including lean-exhaust catalyst may have to be developed to meet future emission standards including ULEV	Two-stroke SI engines are more likely than any alternative powerplant considered here to replace 4-stroke SI engines in the near future in a significant number of vehicles. Two-stroke engines use essentially the same manufacturing technologies as existing engines Moderately better fuel economy than 4-stroke SI engines and ULEV emissions have been demonstrated in small vehicles.	Uncertainty over ability to meet future emissions requirements. More difficult to control noise and vibration than for SI engines. Increased mass of reciprocating components and greater flywheel mass (both necessary due to higher compression ratios) makes diesels slower to "rev" than similar SI engines	Fuel cell technology is still in early stages of development.

Criteria	Gas Turbine	4-Stroke Spark Ignition (Baseline)	2-Stroke Spark Ignition	Diesel	Fuel Cell
Institutional Inertia Barrier	Competing baseline technologies are firmly entrenched. Turbine will have to have significant advantages to justify production.	Baseline	Competing baseline technologies firmly entrenched, but two-stroke is reasonably likely to be adopted by OEMs because it is similar to existing 4-stroke SI powerplants.	Not likely to be developed (again) as a LD automotive powerplant in the U.S. unless it can be developed to have significant advantages over SI engines.	Competing baseline technologies are firmly entrenched. Fuel cells are a greater unknown than 2-strokes and turbines and will have to demonstrate significant advantages over heat engines to justify production.
Marketability Barrier	Clean exhaust, good fuel economy, fuel flexibility, smoothness, excellent low-speed torque (free-turbine engines), quietness, and perceived innovation could make turbine powered vehicles strong sellers. Life-cycle costs, however, must become competitive before consumers will choose to purchase turbine-powered vehicles. Consumers will also need to see demonstrations of success before they commit to ownership of turbine-powered vehicles	Currently favored technology, but subject to increasing cost and complexity due to emissions controls and not intrinsically immune to a viable competitor.	Better specific power and fuel economy than 4-stroke could be a selling point. Public perceptions that 2-stroke engines are noisy, smoky, smelly, and lower-quality may have to be overcome.	Currently favored heavy-duty powerplant. Light-duty diesels have not been successful in the U.S. and would have to overcome perceptions of being noisy, underpowered, and dirty. The diesel fueling infra-structure would have to expand before the OEMs could expect to sell large numbers of light-duty diesel vehicles	Fuel efficiency, quietness, exhaust cleanliness, and potentially low life-cycle costs could make fuel cells a strong future competitor, but consumers will need to see demonstrations of success before they commit to ownership of fuel cell vehicles.

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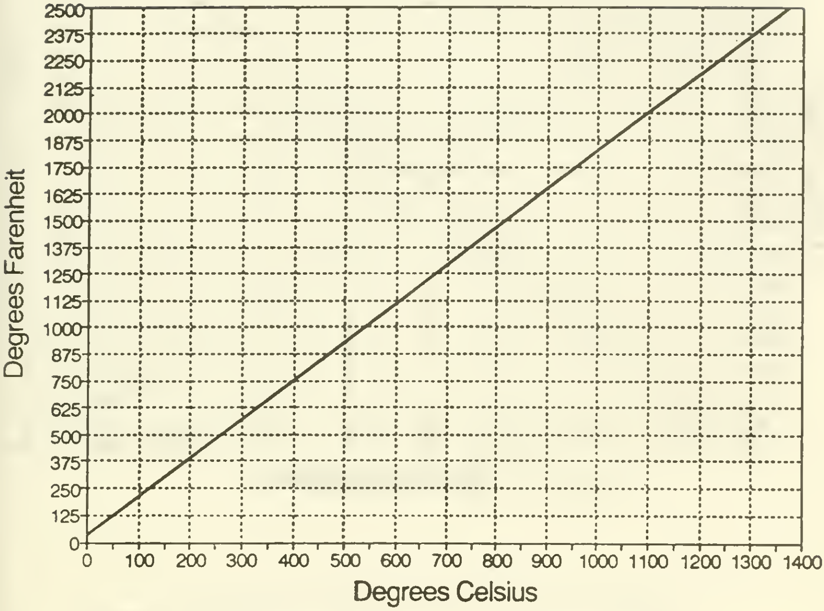
APPENDIX C

U.S. CUSTOMARY/METRIC CONVERSIONS

APPENDIX C

U.S. CUSTOMARY/METRIC CONVERSIONS

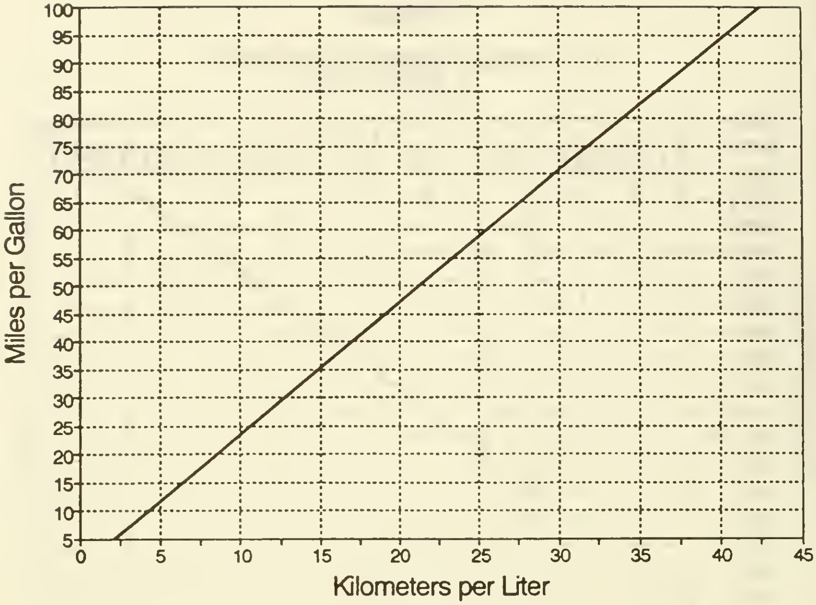


To convert degrees Farenheit to degrees Celsius:

subtract 32, then multiply by 5/9

To convert degrees Celsius to degrees Farenheit:

multiply by 9/5, then add 32

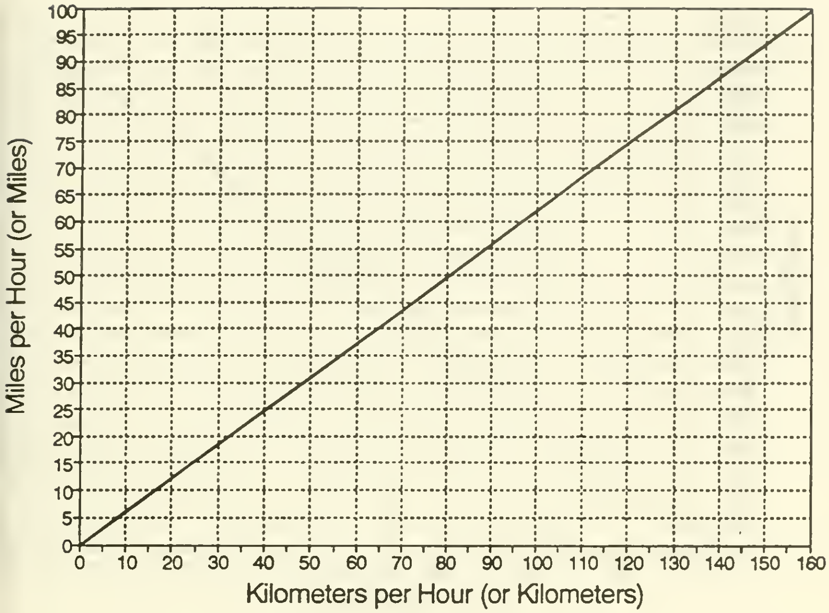


To convert miles per gallon to kilometers per liter:

multiply by 0.4251

To convert kilometers per liter to miles per gallon:

multiply by 2.350

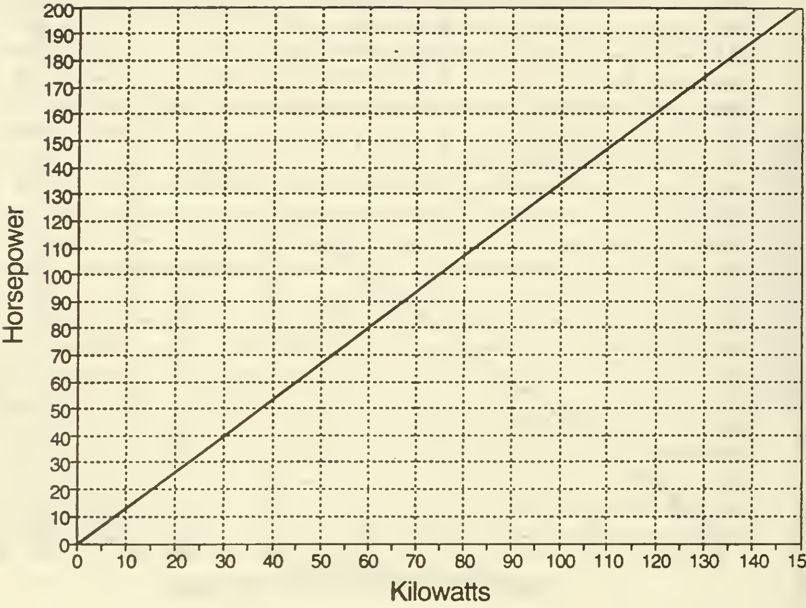


To convert miles per hour to kilometers per hour (or miles to kilometers):

multiply by 1.609

To convert kilometers per hour to miles per hour (or kilometers to miles):

multiply by 0.621

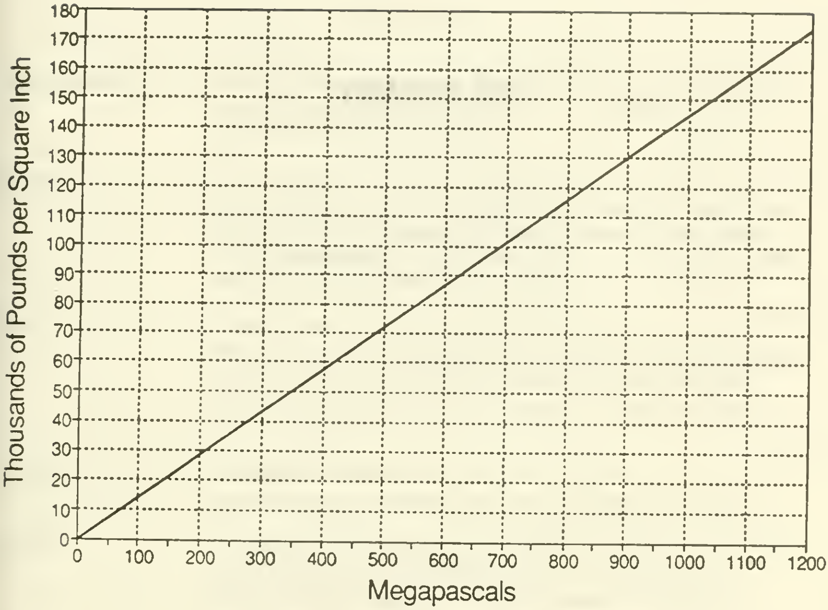


To convert horsepower to kilowatts:

multiply by 0.7457

To convert kilowatts to horsepower:

multiply by 1.341



To convert thousands of pounds per square inch (ksi) to megapascals:

multiply by 6.894

To convert megapascals to thousands of pounds per square inch (ksi):

multiply by 0.1451

GLOSSARY

GLOSSARY

Aftertreatment	Emissions-reducing treatment of engine exhaust after it has left the engine. Examples of aftertreatment devices include catalytic converters and particulate traps.
Brayton	The thermodynamic cycle describing a simple single-shaft gas turbine engine. Often used synonymously to describe a gas turbine engine (i.e., Brayton engine). Engines with two (or more) shafts and/or recuperators are considered to operate on a modified Brayton cycle, but are still called Brayton engines.
Brittle	A material that is unable to withstand significant deformation without failure. The strength of a brittle material is very susceptible to even minor manufacturing flaws because the material cannot deform to relieve internal stress concentrations caused by these flaws (see ductile).
Catalyst	A substance that promotes a chemical reaction between two or more other substances, but which is not itself consumed in the reaction.
Ceramic	A class of materials characterized by ionic or covalent inter-atomic bonds. Ceramics are typically hard, brittle, high melting point materials with low electrical and thermal conductivity, good chemical and thermal stability, and high compressive strengths.
CO	Carbon monoxide. A regulated component of toxic automotive tailpipe emissions.
CO_2	Carbon dioxide. A significant component of automotive tailpipe emissions, CO_2 is an inescapable by-product of burning carbon-containing fuels. CO_2 emissions are nontoxic and are not directly regulated, but CO_2 is believed to contribute to global warming and it is therefore desirable to reduce these emissions.
Composite	A material made tougher by the addition of fibers or particles of a second material. The base material is called the matrix (see monolithic).
Densification	The process in which a green ceramic part is heated to a high temperature, sometimes under pressure, to produce a strong and dense finished part. The densified part is chemically and physically different from the green part.

Diesel	The thermodynamic cycle describing a compression-ignition piston engine. Often used synonymously to describe this type of engine (i.e., Diesel engine). Compression-ignition engines with turbochargers are considered to operate on a modified Diesel cycle, but are still called Diesel engines.
Ductile	A material that is able to deform significantly without failure under an applied stress. The strength of a ductile material is only moderately affected by minor manufacturing flaws because the material can deform to relieve internal stress concentrations caused by these flaws (see brittle).
Effectiveness	The ratio of the amount of energy added to the compressor outlet air by a regenerator or recuperator to the maximum theoretical amount of energy available in the exhaust.
Efficiency (also Thermal Efficiency)	The ratio of useful energy output from a device to the energy supplied, often expressed as a percentage. For heat engines, efficiency can be defined as the ratio of output shaft power to the rate at which chemical energy is supplied in the form of fuel. For fuel cells, or engine-powered gensets, efficiency can be defined as the ratio of electric power generation to the rate at which chemical energy is supplied in the form of fuel.
Free-Turbine Engine	A type of gas turbine engine in which the power-producing turbine is physically separate from the gas generator turbine. Free-turbine engines produce a broad spread of torque across all engine speeds, with the maximum torque occurring at zero output shaft speed. Free-turbine engines are, however, more complex than single-shaft turbines.
Gas Generator	The section of a free-turbine type engine that generates and delivers the high-temperature, high-velocity gas stream to the power turbine. It consists of the compressor, combustion chamber, and the compressor-drive turbine.
Genset	Generator set. A powerplant combined with an electric generator for use in hybrid vehicles.
Gradability	An indication of the hill-climbing ability of a vehicle. Usually expressed as the steepest grade on which the vehicle can maintain a specified speed.

Green	A component formed from a shaped and compressed ceramic starting powder that has not yet been densified.
HC	Hydrocarbons. A regulated component of toxic automotive tailpipe emissions. Reactive HC compounds combine with NO_x in the presence of sunlight to form ozone, a strong respiratory irritant.
Hot-Section	The combustor, nozzles, turbine(s), and associated flowpath in a gas turbine engine.
Hybrid (Electric) Vehicle	A vehicle with two powertrains: One that is powered by a heat engine or fuel cell, and an electric powertrain with the ability to store energy in batteries or a similar device.
Lean	An air-fuel mixture having a greater than stoichiometric proportion of air.
Monolithic	A homogenous material that does not contain a second material for reinforcement (see composite).
NMHC	Non-methane hydrocarbons. A regulated component of toxic automotive tailpipe emissions. NMHCs are sometimes also called reactive hydrocarbons or reactive organic gases (ROG). NMHCs combine with NO_x in the presence of sunlight to form ozone, a strong respiratory irritant.
NO_x	Oxides of nitrogen, generally NO and NO_2. A regulated component of toxic automotive tailpipe emissions. NO_x combines with reactive HC in the presence of sunlight to form ozone, a strong respiratory irritant.
Otto	The thermodynamic cycle describing a four-stroke spark-ignition piston engine. Often used synonymously to describe this type of engine (i.e., Otto engine). Four-stroke spark-ignition engines with turbochargers are considered to operate on a modified Otto cycle, but are still called Otto engines.
PM	Particulate matter. A regulated component of automotive tailpipe emissions. Airborne PM reduces atmospheric visibility and may contribute to respiratory illnesses.
Power	The rate at which work is done. For rotating systems, such as engines, power is proportional to the product of torque and rotational speed.

Power Density	The ratio of a powerplant's peak power to the volume it occupies.
Pressure Ratio	The ratio of the pressure of the compressed air in the combustion chamber of a turbine powerplant to the ambient air pressure.
Prime-Mover	A powerplant that powers a vehicle directly, as opposed to the powerplant used to run the electric generator in a hybrid-electric vehicle.
Recuperator	A fixed-boundary heat exchanger.
Regenerator	A moving-boundary heat exchanger that is alternately exposed to hot exhaust and cool inlet air.
Rich	An air-fuel mixture having a greater than stoichiometric proportion of fuel.
Single-Shaft Engine	A type of gas turbine engine in which the shaft for the gas generator also supplies the mechanical output for the engine. Single-shaft engines produce their maximum torque at or near full speed, decreasing to near zero net torque at idle speed, which is typically about 50 percent of maximum speed. Single-shaft engines are mechanically simpler than free-turbine engines, but require a more sophisticated transmission if they are to be used as prime movers.
Specific Power	The ratio of a powerplant's peak power to its weight.
Stoichiometric	An ideal air-fuel ratio, containing just enough oxygen to oxidize all of the fuel.
Torque	The twisting force exerted by the output shaft of an engine.
ULEV	Ultra-Low Emissions Vehicle. Defined by the California Air Resources Board as a vehicle with emissions of less than 0.04 g/mile of NMHC, 1.7 g/mile of CO, and 0.2 g/mile of NO_x.
Yield	The percentage of parts in a manufacturing process, or step of a process, that survive that process or step.

Q218. On page 331 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is also stated that in FY 1996: "Conduct detailed program evaluations for two additional programs, including the student program. These evaluations are done in concert with the Office of Planning and Assessment (OPA)."

Please provide a status report on these evaluations and copies of any completed evaluations.

A218. A copy of the first of the two program evaluations for FY 1996 is attached. The second evaluation will not be completed until August 1996.

EVALUATION OF THE 1995 HYBRID ELECTRIC VEHICLE CHALLENGE STUDENT COMPETITION SURVEYS

May 3, 1996

Prepared for

TRANSPORTATION TECHNOLOGIES

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Office of Transportation Technologies

Abacus
Technology Corporation

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5454 Wisconsin Avenue, Suite 1100
Chevy Chase, MD 20815

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EVENT OVERVIEW

E.1 INTRODUCTION

The 1995 Hybrid Electric Vehicle (HEV) Challenge was held at the Chrysler Technology Center, in Auburn Hills, MI, from June 5 to June 13, 1995. Students from 31 universities and colleges designed and built hybrid electric vehicles, which used an internal combustion engine in conjunction with an electric motor and batteries for energy storage.

The 1995 student competition was the third and final year of the HEV Challenge, which was first held in June 1993 at the Ford Motor Company headquarters in Dearborn, MI. In 1995, Chrysler Corporation became a primary sponsor and donated Dodge Neons to 11 schools and was the host of the event at the Chrysler Technology Center. Vehicles converted to hybrid electric cars in the 1995 HEV Challenge included: 11 Neons, 11 Saturns, and 9 Escorts. The teams were scored in the areas of vehicle emissions; engineering design; consumer acceptance; acceleration; commuter challenge (handling); energy economy; heating ventilation and air conditioning (HVAC); and range. Each team also provided a technical report which was included in the final scoring. An estimated 440 students attended this year's Challenge with an estimated 860 students involved in building the vehicles.

The U.S. Department of Energy (DOE) has been a sponsor of the Challenge since its inception in 1993. DOE is responsible for event coordination, rule development and enforcement, and logistics. Many additional organizations provided sponsorship for the 1995 HEV Challenge. These sponsors are shown in Exhibit E-1 and are grouped by level of sponsorship.

Most participants in the 1995 HEV Challenge were engineering majors: mechanical engineering (60 percent) and electrical engineering (19 percent). However, students from business, computer science, and other disciplines also participated from schools across the United States and Canada.

A summary of all the vehicle types, event hosts, and locations, and original equipment manufacturers is shown in Exhibit E-2 for each of the HEV Challenges (1993-1995). Exhibit E-3 shows the geographic location of the participating schools.

EXHIBIT E-1
1995 HEV Challenge Sponsors

Level of Sponsorship	Sponsor
Major	U.S. Department of Energy Chrysler Corporation Natural Resources Canada
Gold	Detroit Edison Ford Motor Company General Motors Corporation Saturn Corporation Unique Mobility
Silver	Bridgestone/Firestone Inc. Goodyear Tire and Rubber Company McKenna Industries Siemens Automotive
Bronze	American Yazaki Corp. Consumers Power Hurricane Compressors Sekely Industries, Inc Sun Company Corp.
Associate	Allied Signal Automotive Coltec Industries - Holly Automotive Lear Seating Corporation NSK Corporation Sherex/OPW. Inc Siegel-Roberts

EXHIBIT E-2
Locations, Vehicle Sponsors, and Vehicle Types in the HEV Challenges (1993-1995)

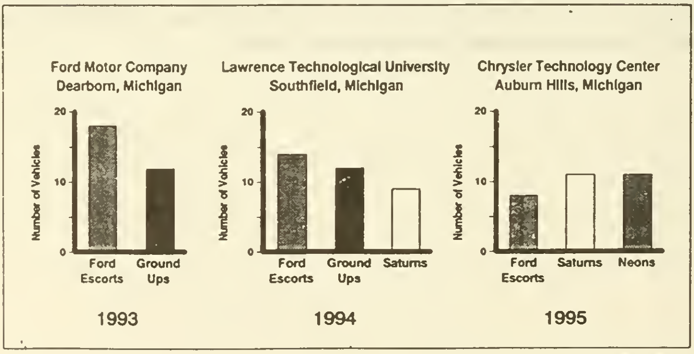

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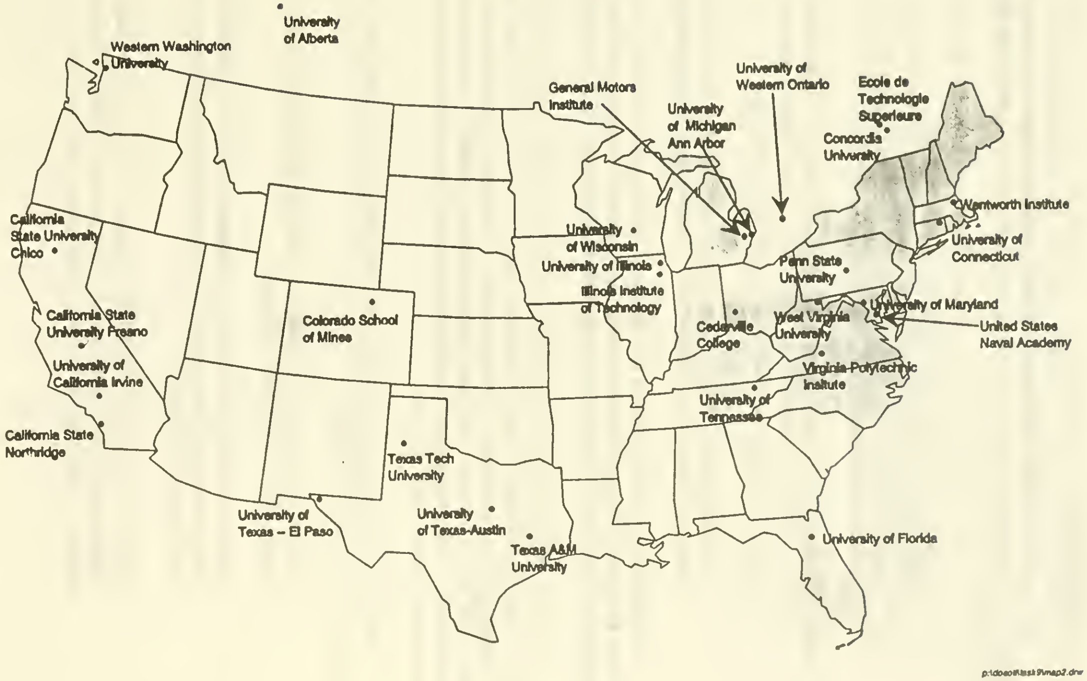
EXHIBIT E-3
Geographic Location of Participating Schools in the 1995 HEV Challenge


University of Alberta
Western Washington University
General Motors Institute
University of Michigan Ann Arbor
University of Western Ontario
Ecole de Technologie Superieure
Concordia University
Wentworth Institute
University of Connecticut
California State University Chico
University of Wisconsin
University of Illinois
Illinois Institute of Technology
Penn State University
University of Maryland
United States Naval Academy
California State University Fresno
Colorado School of Mines
Cedarville College
West Virginia University
Virginia Polytechnic Insitute
University of California Irvine
University of Tennessee
California State Northridge
Texas Tech University
University of Texas – El Paso
University of Texas-Austin
Texas A&M University
University of Florida
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E.2 OBJECTIVES

DOE has specific goals and objectives for its student competitions. The HEV Challenge was designed to meet several educational and technical objectives of DOE. The DOE educational objectives were to:

- Increase the students' abilities as automotive engineers
- Help students to get jobs in the auto industry
- Enable students to interact with other students and sponsors
- Provide students with a valuable experience.

The DOE technical objectives for the HEV Challenge were to:

- Increase the state-of-the-art of alternative fuel technology

- Document student designs and vehicle accomplishments through sessions at the Society of Automotive Engineers (SAE) conferences and published papers.

In addition to these educational and technical objectives, the event also met public relations goals (e.g., stimulate public interest in new fuels and engines), as well as institutional objectives (e.g., DOE cooperation with other sponsors, such as Chrysler Corp.).

In order to help determine the effectiveness of the 1995 HEV Challenge at fulfilling DOE educational objectives, Abacus Technology Corporation staff attended the event and surveyed participating students and faculty advisors. Two separate questionnaires, one for students and one for advisors, were used to gather this information. The student surveys were distributed and collected at the event, and the faculty advisor surveys were mailed out to the advisors several weeks after the event.

This report summarizes the survey results and feedback from participants and spectators. It is organized as follows:

- Chapter 1 is a participant profile and discusses the people and vehicles involved in the 1995 HEV Challenge.

- Chapter 2 examines the benefits for students as well as the event's impact on them and also discusses follow-up research and technology transfer attributable to the student competitions.

- Chapter 3 compares the 1995 HEV Challenge to several other student engineering research competitions (including the 1994 HEV Challenge) with respect to vehicle budgets, student participation, and other areas.

- Chapter 4 is an event evaluation and highlights feedback received from the survey, both positive and negative, regarding the 1995 HEV Challenge. This information is gathered in an effort to help improve future student competitions.

- Chapter 5 provides a technical comparison of the vehicles.

- Chapter 6 provides summary information from student and faculty advisor surveys regarding DOE objectives, along with closing comments on the final year of the Challenge and a synopsis of the favorite aspects of the Challenge.

- Appendices A through C contain copies of the student and faculty advisor surveys, compiled survey results, and final student competition standings.

1.0 PARTICIPANT PROFILE

Abacus Technology Corporation attended the 1995 Hybrid Electric Vehicle (HEV) Challenge and collected student surveys at the event. The surveys were supplied to each team during the event and at the closing banquet. A total of 114 student surveys from 21 teams were returned at the event, and 23 faculty advisor surveys from 23 teams were sent back to Abacus Technology after the event. This report presents the information obtained from these surveys.

An estimated 860 students participated in building vehicles for the 1995 Challenge. This is based on an average number of students per team of 27.8 (as reported on the 23 faculty advisor surveys) and 31 teams. An estimated 440 students attended the event, based on an average of 14.1 persons per team attending the event.

1.1 STUDENT AGE AND CLASS

A range in age of 19 years to 35 years was found, with an average age of 23.5 years. This high average age demonstrates that there are a large number of older students participating in these projects.

As shown in Exhibit 1-1, the majority of the students were seniors. Over 95 percent of the responding students in the 1995 HEV Challenge were either juniors, seniors, or graduate students.

EXHIBIT 1-1
Student Class Profile

Class	Percent of Respondents (113 Respondents)
Freshman	3%
Sophomore	2%
Junior	9%
Senior	72%
Graduate School	14%

1.2 STUDENT MAJOR

The vast majority of the responding students indicated they are mechanical engineering majors (60 percent) or electrical engineering majors (19 percent). This is similar to last year's respondents, 86 percent of whom were mechanical or electrical engineering majors. Other reported majors included: civil, systems, ocean, environmental, and industrial engineering as well as math, materials science, industrial technology, and English.

1.3 STUDENT POST-GRADUATION PLANS

Most students (75 percent) list a *job* as their after-graduation plan. The next highest response was *graduate school* from 24 percent of the respondents.

1.4 CLASS CREDIT

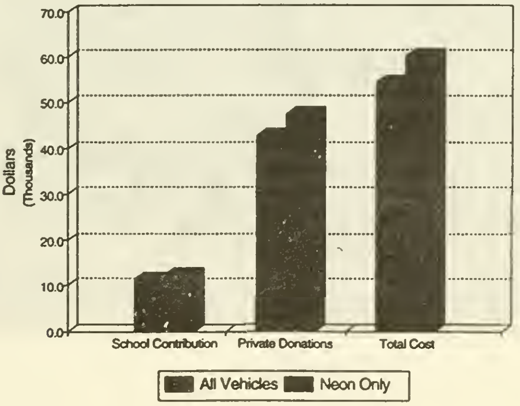
The percentage of students who obtained class credit for working on the vehicle is determined from the faculty advisor survey. This percentage was found to be 51 percent compared to 40 percent for the 1994 event. It could be argued that the students who do not receive credit for this project are at a disadvantage by having to take more classes to fulfill requirements.

1.5 VEHICLE BUDGETS

The average 1995 vehicle budget, as reported by the faculty advisors, was $57,452 compared to $43,674 from last year. The vehicles built for the 1995 HEV Challenge were all conversions (no ground-ups) which would have helped keep the vehicle costs down, however, the Neon conversions (the average reported cost by Neon teams was $62,285) raised the cost above that in 1995.

The school donations often make up the difference between what can be obtained from private sources and the total required to build the vehicle. Exhibit 1-2 shows the averages of the school, private, and total vehicle budgets.

EXHIBIT 1-2
Average School, Private, and Total Vehicle Budgets



1.6 VEHICLE TYPES

In the 1995 HEV Challenge, three different vehicle types competed. Nine Ford Escort station wagons (returning for their third year in the competition) competed in the Escort class (Exhibit 1-3), 11 Saturn sedans (Exhibit 1-4) (returning for their second year in the competition) in the Saturn class, and 11 newly added Dodge Neons competed in the Neon (Exhibit 1-5) class. The ground-up vehicles from the 1993 and 1994 HEV Challenges competed in a different event in southern California in the spring, and therefore did not compete in the 1995 HEV Challenge.

The 1995 HEV Challenge was the first year to incorporate a consumer acceptance score in the event. This led to the use of some convenience items such as air conditioning which were not used in previous years. The Neon class was a particularly complicated conversion because the hybrids were required to use a compressed natural gas (CNG) auxiliary power unit and also have functioning air conditioning. Due to the low energy density of CNG, a larger fraction of the volume of the vehicle was required for storage of the fuel.

EXHIBIT 1-3
University of Wisconsin at Madison's Escort During the Range Event

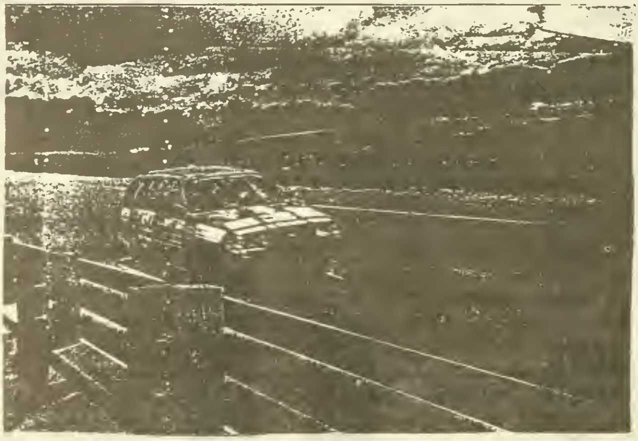


EXHIBIT 1-4
GMI's Saturn During Refueling

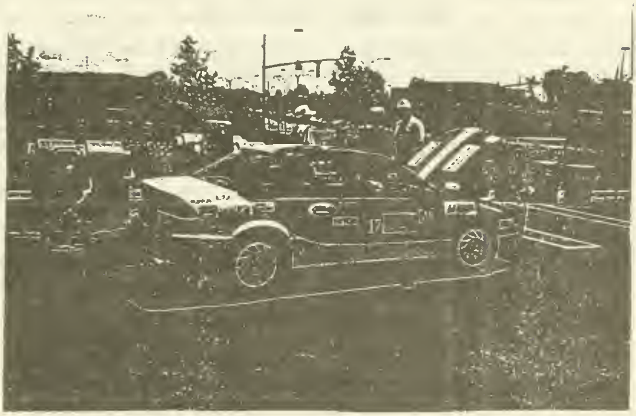


EXHIBIT 1-5
University of Connecticut's Neon

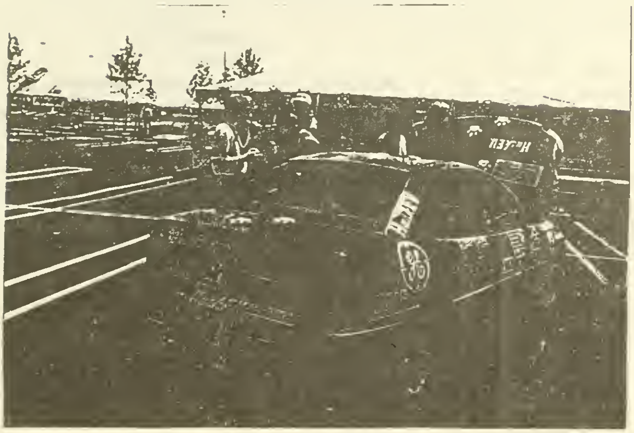


Exhibit 1-6 shows the fuel; hybrid mode; and heating, ventilation, and air conditioning (HVAC) requirements of each of the 1995 HEV Challenge vehicles.

EXHIBIT 1-6
Basic Vehicle Specifications

Vehicle	Fuel Type	Hybrid Mode	Grid Charging	Required Heating, Ventilation, and Air Conditioning
Ford Escorts (1993-1995)	Reformulated Gasoline Methanol (M85) Ethanol (E95)	Range Extender or Charge Depleting	Yes	No
Saturn Sedans (1994, 1995)	Methanol (M85) Ethanol (E95)	Power Assist or Charge Sustaining	No	No
Dodge Neon (1995)	Compressed Natural Gas	Either	Yes	Yes

The Dodge Neon conversions were required to operate on CNG and also have functioning HVAC systems. By combining these two design constraints, the Neon conversions were more difficult to design and build.

2.0 IMPACT AND BENEFITS

Although the students receive a technical education by working on the vehicles, many other benefits to the students are a side effect of their efforts. Students discover what it is like to work in a group and perform with strict time deadlines. Often today engineering students have minimal interaction with their classmates by graduation. Student competitions provide an avenue for this which is seldom found anywhere else. This chapter illustrates some of these benefits. It presents an analysis of the impact and benefit responses received from the 114 student and 23 faculty surveys.

2.1 BENEFITS TO THE STUDENTS

A question on the student survey asked participants to briefly describe how they have benefitted from the car building program. A wide variety of responses were noted (complete responses are found in Appendix B). Many students refer to the increase in their ability to deal with people and teamwork which are not obtained in school. Selected highlights of how students feel they benefitted are listed below.

- Managing Stress
- How to motivate people
- Working on a team
- Hands-on experience
- Going beyond classroom theory
- Experience that cannot be simulated in the classroom
- Working with others
- Interacting with those in the industry
- Building confidence in one's own abilities in:
    - Engineering
    - Communication
    - Social interaction
- Building self confidence and self esteem
- Experience managing an entire project
- Learning about:
    - Design of components
    - Integrating mechanical and electrical components
    - Structural integrity
    - System control strategies
    - Electronics.

2.2 EFFECTS ON STUDENT FUTURE GOALS

Several questions on the student and faculty advisor surveys were designed to assess the competition's impact on the students. All information is included in Appendices A and B.

Each student survey asked how many hours per week and how many weeks were spent on the project. The average responses were 21.7 hours and 26.6 weeks, or 577 hours of total average time per student spent on the project. These numbers are similar to the 1994 HEV Challenge results of 20.6 hours, 31 weeks, and 637 hours.

Students were asked, "*In what ways has participating in this hybrid/electric vehicle project changed your future goals*?" The most common response was that the project helped identify which area the student wants to pursue professionally. Some other ways in which the project affected individual students included:

- *"Increased confidence in my abilities to be part of a team that can create a competitive vehicle."*
- *"Exposure to industry will increase my job marketability."*
- *"With the people and experiences that I've encountered, I find myself excited about the prospects of working in the automotive industry."*

A number of students indicated that the event had no influence on their future plans (many had already decided to pursue an automotive related career). However, from the many positive comments received, it certainly seems the vehicle building programs and the HEV Challenge persuade students to get into careers which utilize their vehicle building and designing experiences. The students learned the importance of teamwork and that no matter what they are working on, every member of the team must do their part, or the result will be a system that does not function.

2.3 FOLLOW-ON RESEARCH AND TECHNOLOGY TRANSFER

The student competitions have proven to form a strong link between government and industry. For example, industry in all areas (all three original equipment manufacturers (OEMs), component suppliers, utilities, racing teams, etc.) participated in the 1995 HEV Challenge. As Bob Larsen of Argonne National Laboratory stated, "*These competitions are a promising paradigm for a new relationship between government and industry.*"

The student competitions provide a testbed for multiple vehicles with precise data collection performed on the vehicles. All of the HEV Challenges have included the Federal Test Procedure (FTP) dynamometer test to determine emissions and fuel efficiency using the hybrid cycle (an arduous time consuming task which is expensive).

Industry does not overlook the educational benefits and influence on future engineers, "*With the considerable challenges facing the auto industry in terms of vehicle development, this program provides Chrysler with an excellent opportunity to develop the quality of engineering students coming into the job market.*" (Francois J. Castaing, Chrysler Vice President of Vehicle Engineering)

Each faculty advisor was asked what follow-on research from government and private industry sources can be attributed to their student competition experience. Each advisor was also asked about technology transfer which may have accompanied their student competition efforts. One of the goals of 1995 HEV Challenge was to provide opportunities for technology transfer. All of the responses for both questions are contained in Appendix B, and highlights are listed below:

- Concordia University has loaned its car to the City of Montreal for evaluation in everyday city use.

- The University of Alberta's HEV is being studied by a major sponsor.

- The University of Maryland has a contract with Westinghouse and the National Renewable Energy Laboratory.

- The University of Texas at Austin has received funding for two, large natural gas vehicle projects as a result of an earlier competition, the Natural Gas Vehicle Challenge.

- Western Washington University has received contracts from DOE and the Department of Defense for development of thermophotovoltaic power generators. (This research was a product of Western Washington's efforts for Sunrayce 90 and 93).

- Wentworth Institute of Technology will be starting a Northeast regional training laboratory for Alterative Fuel Vehicles and is now working with Square D and Westinghouse on a Main Power Disconnect Switch for electric vehicle use.

- California State University - Chico reported technology transfer with both the motor manufacturer and battery manufacturer.

3.0 EVENT COMPARISON

The U.S. Department of Energy (DOE) has conducted student and faculty advisor surveys at several different student competitions. This chapter presents results of a comparison of information from the 1995 Hybrid Electric Vehicle (HEV) Challenge survey with information from three previous surveys. The surveys used in this comparison were conducted at: (1) the 1994 HEV Challenge, (2) 1993 Phoenix 500, and (3) the 1994 Richmond EV Grand Prix. The last two events involved production vehicles converted into electric vehicles, whereas the 1994 HEV Challenge involved production vehicles converted into HEVs and student-built ground-up HEVs. The 1993 Phoenix 500 and the 1994 Richmond EV Grand Prix were high school events, while the 1994 and 1995 HEV Challenges were college events. This section provides a comparison of some of the survey results of the four competitions.

3.1 NUMBER OF STUDENTS PER TEAM

Student competitions provide an outstanding forum for large groups of students to work together. Several 1995 HEV Challenge faculty advisors reported teams of 50 or more students. The largest team reported was 80 students (Texas A&M University). Exhibit 3-1 shows the average number of students working on the vehicles for the events listed above.

EXHIBIT 3-1
Average Number of Students Working on Vehicles

Event	Average Number of Students per Vehicle
1995 HEV Challenge (Colleges)	28
1994 HEV Challenge (Colleges)	33
1993 Phoenix 500 (High Schools)	42
1994 Richmond EV Grand Prix (High Schools)	57

3.2 AVERAGE VEHICLE BUDGET COMPARISON

Exhibit 3-2 compares the average vehicle budget for all four events. The 1995 HEV Challenge average vehicle budget is the most expensive and is more than $10,000 greater than the 1994 HEV Challenge. The simpler high school electric vehicles are only a fraction of either of the HEV Challenge average vehicle budgets.

EXHIBIT 3-2
Average Vehicle Budget Comparison

Event	Average Vehicle Budget
1995 HEV Challenge	$57,452
1994 HEV Challenge	$43,674
1993 Phoenix 500	$8,876
1994 Richmond EV Grand Prix	$9,988

3.3 AVERAGE TIME SPENT BUILDING VEHICLE

The average time spent building a vehicle as reported by the students for the 1995 HEV Challenge, with 21 teams reporting, was 26.6 weeks or 6.13 months. Exhibit 3-3 compares this to the 1994 HEV Challenge, the 1994 Richmond EV Grand Prix, and the 1993 Phoenix 500.

EXHIBIT 3-3
Comparison of Average Time Spent Building Vehicle

Event	Time (Months)
1995 HEV Challenge	6.13
1994 HEV Challenge	10.24
1993 Phoenix 500	3.6
1994 Richmond EV Grand Prix	3.5

The 1995 HEV Challenge vehicles were built in a much shorter amount of time than the 1994 HEV Challenge vehicles. This is largely due to the fact that the 1994 event included ground-up vehicles, which generally take longer to build than the conversions in the 1995 HEV Challenge. Both of the HEV Challenges did, however, have a much longer build time than either of the high school EV events which is expected considering the difficulty of the design and build of the vehicles.

3.4 AVERAGE NUMBER OF HOURS PER WEEK

Another comparison is of the average number of hours per week spent on the project, as indicated by the responding students. Exhibit 3-4 shows the average number of hours per week for the four events.

EXHIBIT 3-4
Comparison of Average Number of Hours per Week Spent on Project

Event	Hours per Week
1995 HEV Challenge	21.7
1994 HEV Challenge	20.6
1993 Phoenix 500	22.5
1994 Richmond EV Grand Prix	13.5

As shown in Exhibit 3-4, the 1995 HEV Challenge students spent an average of one more hour per week than the 1994 HEV Challenge students. The roughly 20 hours per week spent by the students in three of the four competitions is a great deal of time to spend on a project (particularly for the high school students). Few projects generate the motivation for students to provide more than 20 hours per week in addition to their classes.

3.5 AVERAGE TOTAL HOURS PER VEHICLE

Using the averages calculated for students per team, time spent building the vehicle, and hours per week, an average was calculated for the total number of hours spent on a vehicle. As shown in Exhibit 3-5, the average total hours per vehicle for the 1995 Challenge vehicles was 24,130 hours, somewhat less than for the 1994 vehicles. It should be noted that these hours represent a period of learning as well as actual vehicle building.

EXHIBIT 3-5
Comparison of Average Total Hours per Vehicle

Event	Hours per Vehicle
1995 HEV Challenge	24,130
1994 HEV Challenge	30,183
1993 Phoenix 500	14,742
1994 Richmond EV Grand Prix	11,671

4.0 EVENT EVALUATION

This chapter summarizes comments from the student and faculty advisor surveys on the best parts of the 1995 Hybrid Electric Vehicle (HEV) Challenge and recommended improvements for future student competitions.

4.1 BEST PARTS OF THE 1995 HEV CHALLENGE

The following two sections discuss the feedback received from the 23 faculty advisor surveys and the 114 student surveys which asked about the best parts of the 1995 HEV Challenge. All responses are included in Appendix B.

4.1.1 FACULTY ADVISOR SURVEY FEEDBACK

Each faculty advisor survey asked, "*What did you like best about the 1995 HEV Challenge?*" Of the 23 responses, 9 mentioned *improved organization* or *event organization.* This is a large improvement over the previous years when organizational problems have been a common complaint. One faculty advisor wrote, "*Communication at the competition was greatly improved over 1994.*" Several faculty advisors reported that teamwork and the team spirit were the things they liked best about the 1995 HEV Challenge. Another advisor wrote, "*Meeting and working with the other teams and the organizers. The exchanging of ideas, giving help to one another was a great experience for all.*"

It was clear from the feedback that the advisors were very impressed with this event. One advisor wrote, "*Well organized, good student accommodation, good information. A great event.*" In the past, organization and communication have been problem areas, and the 1995 event seems to have alleviated some of the problems. Much of the success of this year's event can be attributed to the "lessons learned" from previous years' survey results and other forms of feedback.

4.1.2 STUDENT SURVEY FEEDBACK

In an effort to learn more about the student reactions to the 1995 HEV Challenge, each student survey asked, "*What do you think was the best part of the HEV Challenge?*" Many varied responses were received for this question, but one response that was seen more than any other was *teamwork* and the experience of *seeing other designs and working with other teams.* Thirty-two of the 114 responding students mentioned teamwork or learning from others as being the best part of the competition. This is an area which is almost completely overlooked in conventional engineering curricula. Most engineering students graduate with only slight interactions with colleagues and learn very little from other students. Student competitions provide an avenue for communication that is seldom found anywhere else. A few of the many interesting responses are listed below.

- *"The competition in the Escort class conversions. The teams were very courteous, and it was nice to discuss the various solutions used by different groups given a common problem."*

- *"The feeling of seeing a finished product, a sense of accomplishment. Also, being able to see other ideas that students have, and the modifications made on each different vehicle type."*

- *"Witnessing the project go from paper to parts to a working machine is a very gratifying feeling that is rare in university education."*

- *"Seeing an idea materialize into a working system and watching it compete with others who have built a device to do the same thing. Sometimes they solved the problem in a manner I had never thought of."*

- *"The best part was that we all started with exactly the same car. It was very interesting to see what decisions other teams had made concerning placement of vital components."*

- *"Meeting fellow engineers from North America."*

- *"(It) gave me an opportunity to see how the auto industry functions and what it takes to become a member of a large auto-manufacturer."*

4.2 IMPROVEMENTS TO FUTURE STUDENT COMPETITIONS

One of the purposes of the student and faculty advisor surveys was to get feedback on how to improve future student competitions. The following sections discuss feedback on this subject from the students and advisors.

4.2.1 FACULTY ADVISOR FEEDBACK

Each faculty advisor was asked, "*What improvements would you like to see in future student competitions*?" The most common response was *improved rule enforcement*. The second most common response was that *cost-effectiveness* should be reinstated in the event scoring because it is such an issue in modern engineering.

One item noticeable in its absence was the lack of comments regarding organization. In the past, other surveys have shown organization was a point of concern. It is likely that an emphasis on improving organization, based on faculty advisor feedback received from last year's event, helped alleviate complaints.

4.2.2 STUDENT FEEDBACK

Although in previous student competitions most students have enjoyed the event a great deal, there will always be room for improvement. In the 1995 HEV Challenge student survey, each student was asked, "*What changes or improvements would you like to see in future student competitions?*" The following paragraphs address some of these concerns.

In the past the most common complaint among students has been the *lack of organization* or *lack of rule enforcement*. In 1994, 19 percent of the students mentioned *lack of rule enforcement* alone. This year (1995), 20 percent of the students responded with *lack of rule enforcement, improve organization,* and *improve communication* combined. A few highlights of student responses as to how the competition can be improved are listed below.

- *"Instead of one big group meeting for all classes, have individual class (Neon, Escort, Saturn) meetings every morning to remind teams of the day's events and any changes that have occurred; that way, all teams will be working toward the same goal."*

- *"Do not change requirements after the design process has started; when rules change quickly it can be expensive and time consuming for schools to back track and redo a design; this can and has resulted in cars arriving to a competition in a less-than-finished state."*

- *"Leave blocks in the schedule that late qualifying events can be easily scheduled for teams having trouble. The organizers and workers did a very good job of helping teams when they could; it just might make it easier to make schedule changes if the original schedule was slightly more flexible. The catch to all this is the competition itself does not need to be any longer (timewise)."*

5.0 TECHNICAL ANALYSIS/COMPARISON OF THE STUDENT VEHICLES

All of the hybrid electric vehicles (HEVs) which competed in the 1995 HEV Challenge used a spark ignition engine (auxiliary power unit), an energy storage device (batteries in this case), and an electric motor.

There are two types of hybrid configurations. A series hybrid (see Exhibit 5-1) is one in which the electric motor provides all of the tractive force at the wheels (the auxiliary power unit only produces electricity to power the electric motor). The second configuration is parallel. In a parallel hybrid (see Exhibit 5-2) the auxiliary power unit also is mechanically linked to the wheels.

EXHIBIT 5-1
Series Hybrid Configuration

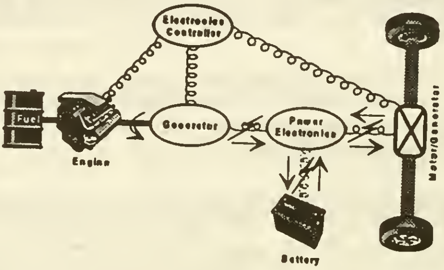
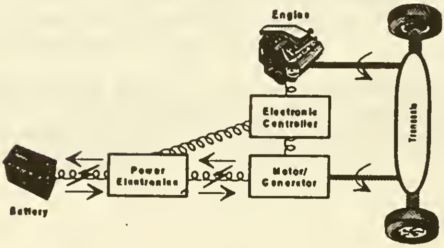
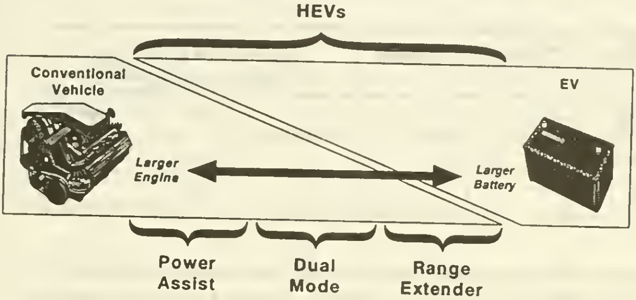


EXHIBIT 5-2
Parallel Hybrid Configuration



As shown in Exhibit 5-3, HEV system designs range from the power assist hybrid, which uses a larger auxiliary power unit combined with limited energy storage to act as a load leveler in high power demand situations, to the range-extender hybrid, which utilizes a smaller auxiliary power unit to increase the vehicle range in conjunction with a larger amount of energy storage. The power assist hybrid is more like a conventional vehicle while the range-extender hybrid is more like an electric vehicle.

EXHIBIT 5-3
Hybrid Powertrain Configurations



The following sections examine the various powertrains used in the 1995 HEV Challenge. Vehicle emissions and fuel economy results are also examined for the 1995 vehicles.

5.1 AUXILIARY POWER UNIT

The auxiliary power unit in all of the student vehicles was a spark ignition engine which operated on compressed natural gas, ethanol (E85), methanol (M85), or reformulated gasoline. Engines ranged in size from the 2.0 liter stock Chrysler (140 hp) and 1.9 liter Ford ngines (90 hp) to a 0.62 liter engine (20 hp) built by Kawasaki.

In general, the series hybrids (12 vehicles) used smaller auxiliary power units (avg. = .8 liter, 32.3 hp) in a range extender mode, while the parallel hybrids (17 vehicles) used arger auxiliary power units (avg. = 1.2 liter, 81.8 hp).

5.2 ENERGY STORAGE

All of the vehicles in the 1995 HEV Challenge used chemical batteries for energy storage. The largest amount of energy storage used was 31.6 kWh at c/20, and the smallest amount of energy storage was 3.15 kWh at c/20 (discharge rate of full discharge in 20 hrs). Exhibit 5-4 shows the various types of batteries used and the number of vehicles utilizing each type.

EXHIBIT 5-4
Batteries Used in the 1995 HEV Challenge Vehicles

Battery Type	Number of Vehicles	Median Energy Storage Capacity at c/20 (kWh)
Lead-Acid	23	8.02
NiCad	5	6.80
NiMH	1	31.56

The majority of student competition vehicles have used lead-acid batteries due primarily to their cost advantage. This year, six vehicles used non lead-acid batteries as shown in Exhibit 5-4.

5.3 OVERALL PERFORMANCE RESULTS

Student vehicles do not have the high budgets available to the national laboratories or the manufacturers, but several very impressive results were demonstrated nonetheless. Some of the best results turned in by student vehicles in the 1995 HEV Challenge are presented in this section. Data are provided by Argonne National Laboratory.

5.3.1 FUEL ECONOMY

Fuel economy was calculated during the Federal Test Procedure (FTP) for the Emissions Event. The change in energy stored in the batteries (state-of-charge) of the vehicle was corrected for and included into the corrected fuel economy. Two of the Saturn hybrids were able to improve significantly on the fuel economy of the stock Saturn despite 39 percent and 64 percent higher vehicle weights. Several Escorts and Neons were able to achieve similar fuel economy to the corresponding stock vehicle although their weights were nearly 50 percent higher than the stock vehicle. Exhibit 5-5 lists the best fuel economy results for selected schools.

EXHIBIT 5-5
Fuel Economy Leaders

School	Class	Fuel Economy (miles/gal)	Vehicle Weight (lbs)	Percent Heavier Than Control Vehicle
Ecole de Technologie Superieure	Saturn	42.2	3184	39%
California State University - Chico	Saturn	32.2	3760	64%
Cal. State Fresno	Saturn	27.0	3166	38%
1991 Saturn SL2	Stock	28.7	2289	--
Wayne State University	Escort	26.6	3960	65%
University of Alberta	Escort	25.9	3558	48%
University of California - Irvine	Escort	25.4	3687	54%
1992 Ford Escort	Stock	32.6	2398	--
Texas Tech. University	Neon	23.8	3466	49%
University of Tennessee	Neon	23.1	3291	41%
Western Washington University	Neon	21.7	3468	49%
1995 Chrysler Neon	Stock	28.7	2327	--

Note: Numbers are based on data obtained by Argonne National Laboratory.

5.3.2 EMISSIONS

Probably the most difficult aspect of designing an HEV is minimizing the emissions. Many of the student vehicles have less than optimal systems due to a shortage of both money and time and access to testing facilities. There were, however, some exceptional emissions results at the 1995 HEV Challenge.

The University of Tennessee was able to achieve below 1/2 of ultra-low emissions emission levels. This was the best of any vehicle at the competition and demonstrates some very impressive results. This vehicle operated on compressed natural gas and used a 1 liter Geo Metro 3 cylinder engine in a parallel configuration. The state-of-charge corrected numbers for the University of Tennessee car are shown in Exhibit 5-6.

EXHIBIT 5-6
University of Tennessee Emission Test Results (FTP)

Vehicle	Non-Methane Hydrocarbons (grams/mile)	Carbon Monoxide (grams/mile)	Nitrogen Oxides (grams/mile)
Ultra-Low Emission Vehicle	0.04	1.7	0.2
University of Tennessee (state of charge corrected values)	0.019	0.504	0.05

These are the lowest emission levels of any student competition vehicle and rival the cleanest vehicles produced today. Through strict engine control strategy and careful emissions control, the University of Tennessee demonstrated particularly impressive results for a student-built vehicle with limited dynamometer testing facilities and development time.

6.0 SUMMARY OF THE 1993-1995 HEV CHALLENGES

This chapter provides a summary of the results from the 1995 Hybrid Electric Vehicle (HEV) Challenge student and faculty advisor surveys as well as a general overview of the competition and the 1993 and 1994 events.

6.1 FINAL YEAR OF THE CHALLENGE

The 1995 competition was the third and final year of the HEV Challenge. In 1995, 31 schools built HEVs. An estimated 860 students in 31 teams participated in building vehicles for the 1995 HEV Challenge. An estimated 440 students attended the event, which was hosted by Chrysler at the Chrysler Technology Center.

A total of 114 student surveys from 21 teams were returned at the event and 23 faculty advisor surveys from 23 teams were sent back to Abacus Technology Corporation after the event. The overall tone of the comments was very positive with the number of "*lack of organization*" complaints greatly reduced from the 1994 event. A synopsis of the information gathered is as follows:

- A student age range of 19 years to 35 years was found, with an average age of 23.5 years.
- Students' major - mechanical engineering (60 percent), electrical engineering (19 percent).
- The average vehicle budget, as reported by the faculty advisors, was $57,452.
- Nine Ford Escort station wagons (returned for the third year of competition), 11 Saturn sedans (returned for the second year of competition), and 11 newly added Chrysler Neons competed.
- Twenty-one of the 23 responding faculty advisors said they would participate in another student competition. Only 2 said they would not.
- The 12 series hybrid vehicles used smaller auxiliary power units (avg. = 0.8 liter, 32.3 hp) in a range extender mode, while the 17 parallel hybrid vehicles used larger auxiliary power units (avg. = 1.2 liter, 81.8 hp).
- Twenty-three vehicles used lead-acid batteries, 5 used nickel-cadmium batteries, and 1 used a nickel/metal hydride battery.
- The University of Tennessee was able to achieve below 1/2 of the ultra-low emissions levels.

6.2 LOCATION OF HEV CHALLENGES (1993-1995)

The 1995 student competition was the final year of the HEV Challenge. Ford Motor Co., Saturn Corp., and Chrysler Corp. each sponsored the event in 1993, 1994, and 1995, respectively. Exhibit 6-1 lists the locations of each event.

EXHIBIT 6-1
Locations of the HEV Challenges (1993-1995)

Year	Location of Event
1993	Ford Motor Co. headquarters (Dearborn, MI)
1994	Lawrence Technological University (Southfield, MI)
1995	Chrysler Technology Center (Auburn Hills, MI)

6.3 STUDENT COMPETITORS IN THE HEV CHALLENGES COMPARED TO OTHER EVENTS

The HEV Challenges were the largest U.S. Department of Energy (DOE) sponsored student competitions since their formation in 1988. Roughly 30 teams and 400 students attended each event, and as many as nearly 1,000 students worked on the design and build of vehicles for each event (based on data from faculty advisor surveys).

The students who worked on the vehicles were primarily mechanical and electrical engineering majors (79 percent of the 1995 participants, as determined from the student surveys), but many different majors were reported. Most of the students were seniors (72 percent in 1995) and graduate students (14 percent in 1995), but students ranging in age from 19 years to 38 years have returned surveys in the 1994 or 1995 HEV Challenge.

6.4 VEHICLES USED IN THE HEV CHALLENGES

The HEV Challenge was the premier DOE sponsored student competition from 1993 through 1995. The event involved more vehicles (94, counting all vehicles) than any other DOE event. The next largest event was the Natural Gas Vehicle Challenge, which ran from 1991 through 1993. This event had roughly 20 vehicles participating per year.

The vehicles used in the HEV Challenges have been the most complicated student competition vehicles ever built for DOE student competitions. These vehicles, which incorporated an internal combustion engine and electric drivetrain, required the greatest amount of design efforts and manufacturing labor. Each year a new class of cars was added. Exhibit 6-2 lists the competing vehicles in each event.

EXHIBIT 6-2
Competing Vehicles in the HEV Challenges (1993-1995)

Year	Vehicles
1993	18 Ford Escorts 12 Ground-up Vehicles
1994	14 Ford Escorts 12 Ground-up Vehicles 9 Saturn Sedans
1995	9 Ford Escorts 11 Saturn Sedans 11 Dodge Neons

6.5 FAVORITE ASPECTS OF THE CHALLENGE

The favorite aspects of the HEV Challenges (from the 1994 and 1995 surveys) have proven to be teamwork and meeting other people. The following paragraphs highlight the best part of the competitions as reported by the participants.

In 1995 each faculty advisor survey asked, "*What did you like best about the HEV Challenge*?" Of the 23 responses, 9 mentioned *improved organization* or *event organization*. One advisor wrote, "*Meeting and working with the other teams and the organizers. The exchanging of ideas, giving help to one another was a great experience for all.*"

In an effort to learn more about the student reactions to the 1995 HEV Challenge, each student survey asked, "*What do you think was the best part of the HEV Challenge?*" Many varied responses were received for this question, but one response that was given more than any other was *teamwork* and the experience of *seeing other designs and working with other teams*. Thirty-two of the 114 responding students mentioned teamwork or learning from others.

In 1994 the students were asked, "*What do you think is the best part of the HEV Challenge to date?*" Many different responses were given, including *seeing other schools compete*, *competing the vehicles*, *all parts*, *educational value*, *data collection*, and one student responded, *the skits*. (Each team participated in a skit with some very interesting acting talents uncovered.) The most common response was *seeing other students and vehicles*, from about one-fifth of the respondents. The next most common responses as to the best part of the HEV Challenge were *Education* (15 percent) and *all* parts *were the best* (13.1 percent).

From these responses it appears that over three years the HEV Challenge has transitioned and developed into a more organized and enjoyable experience for all participants. It has been the premier event and much of the technology will be used in other student competition vehicles in the future.

EXHIBIT A-1
Student Survey Responses (Page 1 of 27)

School	Age	Year	Major	Gender	G.P.A	After Graduation	Hours/ week	# of weeks
California State University - Northridge	26	Sr.	ME	--	2.9	Job	15	14
	22	Sr.	ME	M	--	Job and Graduate School	7	17
	25	Sr.	ME	M	--	Job and Graduate School	15	15
	25	Sr.	Eng.	M	3.0	Graduate School	6	17
	23	Sr.	ME	M	--	Job and Graduate School	15	20
	24	Sr.	ME	M	2.5	Job and Graduate School	7	34
California State University- Chico	28	Sr.	ME	M	--	Job	20	10
	22	Sr.	ME	M	2.5	Job	35	20
	27	Sr.	CE	F	--	Peace Corps	--	--
	28	Sr.	ITSC	M	--	Job	30	20
Cedarville College	23	Sr.	ME/	M	3.6	Graduate School	20	30
	--	--	Math	--	--	--	--	--
	24	Sr.	ME	M	--	Job	15	25
	22	Sr.	ME	M	3.08	Job	25	30
Concordia University	25	GS	ME	M	3.69	Job	40	20
	25	GS	ME	M		Job	60	50
	28	.GS	Computer Science	M		Job	10	20
	23	Jr	EE	M	3.01	Job and Graduate School	10	11
	25	Jr	EE	M	3.51	Job and Graduate School	20	15
Ecole de Technologie Superieure	21	GS	--	M	--	--	70	--
GMI Engineering and Management	--	Sr.	ME	M	--	Job and Graduate School	20	20
	23	Sr.	ME	M	3.0	Job and Graduate School	10	20
	23	Sr.	ME/EE	M	--	Job and Graduate School	20	20
	19	Fr.	ME/EE	--	--	Job	20	24

EXHIBIT A-1
Student Survey Responses (Page 2 of 27)

School	Age	Year	Major	Gender	G.P.A	After Graduation	Hours/ week	# of weeks
United States Naval Academy	22	Sr.	ME	M	--	Job	4	18
	22	GS	ME	M	2.3	Job	7	18
	22	GS	Systems Engineering	M	3.7	Job	10	16
	22	Sr.	ME	M	3.33	Navy	5	21
	20	Soph.	Ocean Engineering	F	4.0	Navy	6	16
	21	Sr.	ME	M	3.5	Navy	6	21
	22	GS	ME	M	3.2	Nuclear Power	5	15
Penn State University	22	Sr.	EE/CS	M	3.8	Job and Graduate School	80	6
	25	Sr.	ME	M	2.55	Job and Graduate School	3	25
	22	Sr.	ME	M	--	Job	--	30
	33	GS	ME	M	3.5	Job and Graduate School	20	52
Texas A+M University	21	Sr.	EE	M	3.3	Job	12	20
	23	Sr.	ME	M	3.0	Graduate School	5	16
	33	GS	ME	M	3.75	Job	16	1
	22	Sr.	EE	M	3.54	Job	15	26
	25	GS	EE	M	--	Job	30	4
	24	Sr.	EE	M	2.8	Job	20	20
	22	Sr.	EE	M	2.8	Job	20	21
	25	Sr.	EE	M	--	Job	40	12
	35	Sr.	EE	M	3.7	Job	15	40
	23	Sr.	ME	M	3.25	Job	40	4
	--	GS	EE	M	4.0	Job	40	25
	24	Sr.	EE	M	2.8	Job	20	18
	38	Sr.	ME	M	--	Job	10	40
University of Alberta	20	Jr	ME	F	--	Job	2	20
	23	GS	ME	M	--	Job	40	52
	22	GS	ME	M	--	Graduate School	8	20
University of Connecticut	22	Sr.	ME	M	2.5	Job	30	30
	22	Sr.	ME	M	3.0	Job	10	18
	22	Sr.	ME	M	3.2	Graduate School	15	60

EXHIBIT A-1
Student Survey Responses (Page 3 of 27)

School	Age	Year	Major	Gender	G.P.A	After Graduation	Hours/ week	# of weeks
University of Illinois	22	Sr.	ME	M	--	Job	25	45
University of Florida	27	GS	EE	M	3.8	Job	25	20
	23	Sr.	ME	M	3.92	Job	35	40
	22	Sr.	ME	M	3.95	Job	63	50
	23	Sr.	ME	M	3.5	Graduate School	30	52
	20	Jr	ME	M	3.2	Job	5	25
	30	Sr.	ME	M	2.7	Job	2	40
	23	Sr.	Environmental Eng	F	--	Job	5-60	60
	23	Sr.	EE	M	3.7	Job	80	9
	22	Sr.	ME	M	--	--	4	35
	20	Jr	ME	F	3.33	Job	20	2
	25	Sr.	Industrial Eng.	M	--	Job	6	40
University of Maryland	25	Sr.	ME	M	2.7	Job	15	20
	28	Sr.	ME	M	3.2	Graduate School	20	90
	23	Sr.	ME	M	--	Job	15	16
	25	Sr.	ME	M	2.4	Job	10	20
	23	GS	ME	M	--	Job	70	--
	22	Sr.	ME	M	2.8	Job	20	20
	24	Sr.	ME	M	--	Job	--	52
	23	Sr.	ME	M	3.0	Job	20	15
	25	Sr.	ME	M	3.2	Job	10	16
	21	Sr.	ME	M	--	Job	20	15
	22	Sr.	ME	M	3.0	Job	--	--
	21	Sr.	ME	F	3.9	Job	10	40
	23	Sr.	ME	M	3.0	Job	20	45

EXHIBIT A-1
Student Survey Responses (Page 4 of 27)

School	Age	Year	Major	Gender	G.P.A	After Graduation	Hours/ week	# of weeks
University of Michigan	21	Sr.	AE	M	--	Job	40	30
	23	Sr.	Material Sci., ME	M	--	Graduate School	22	60
	20	Sr.	EE	F	3.0	Graduate School	25	52
	21	Sr.	EE	M	3.9	Graduate School	40	30
	22	Sr.	ME	M	3.3	Job	20	50
	20	Sr.	EE	F	--	Job	10	25
	21	Sr.	ME	F	3.9	Job	20	25
University of Tennessee	22	Sr.	ME	M	3.1	Job	10	30
	31	Sr.	ME	M	3.5	--	25	20
	21	Sr.	ME	M	3.4	Job	30	20
	22	Sr.	EE	M	2.8	Job	10	30
	23	Sr.	ME	F	3.0	Job	30	20
University of Western Ontario	24	Sr.	ME	M	--	Job	20	10
	23	Sr.	EE	M	--	Job	3	20
	19	Fr.	ME	--	--	--	25	7
	22	Soph.	ME	M	--	Job	10	6
	28	Sr.	English	M	--	Graduate School	10	52
	18	Fr.	Eng	M	--	Job	10	16
Virginia Polytechnic Institute and State University	22	Sr.	EE	M	3.0	Graduate School	30	52
	23	GS	EE	M	3.6	Graduate School	20	30
	21	Jr.	ME	M	2.9	Job	10	28
	20	Jr.	EE	M	--	Job	12	41
	26	GS	ME	M	3.5	Job	25	30
Wayne State University	25	Sr.	ME	F	--	Job	35	24
	22	Sr.	ME	M	3.74	Job	20	30
	24	Sr.	ME	M	3.0	Job and Graduate School	30	32
	22	Sr.	CE	M	3.1	Job	30	28
West Virginia University	23	Sr.	ME	M	--	Graduate School	6	30

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School	Age	Year	Major	Gender	G.P.A	After Graduation	Hours/ week	# of weeks
Western Washington University	29	Sr.	Industrial	M	3.0	Job	40	40
	--	--	technology/	--	--	--	--	--
	28	Sr.	Vehicle Design	M	--	Job	30	40
	21	Jr.	ME	M	3.3	Graduate School	9	36
	20	Jr.	Ind.tech	M	3.5	Job	30	30
	25	Sr.	Ind.tech	M	3.2	Job	--	4
	29	Sr.	Ind.tech	M	3.65	Job	--	--
	27	Jr.	Ind.tech	M	3.0	Job	60	5
	25	Sr.	Eng. tech	M	3.25	Job	--	40
			Ind.tech					
Average	23.5						21.7	26.6

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Student Survey Responses (Page 6 of 27)

School	In What Ways Has Participating In This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
California State University, Northridge	It has not.	I now realize that a very important part of designing and developing a system is also testing and redesigning.
	Change in focusing on related aspects of mechanical engineering.	Learned about electrical work in automotive applications.
	I have decided to move further on to graduate work with hybrid cars.	It has definitely been a challenging program to design a product that works to the specifications required.
	It really doesn't because I have always liked cars.	I learned to perform under pressure. I learned to deal with people.
	It has made me really think about the future.	It has given me hands-on experience, and also a chance to interact with other students and interact ideas.
	It has reinforced my decision to stay with the automotive industry.	It has given me an in-depth view of the needs of the automotive community. I have also gained experience that is important to the industry.
California State University, Chico	It hasn't. I still wish to enter the automotive industry.	Hands-on experience.
	I don't know.	I have learned how to deal with people.
	I may do graduate work in ME.	I learned a lot about electrical systems. I also learned about the reality of keeping a project like this together.
	I have always had an interest in working in the automobile industry. This competition has only increased my motivation to do so.	My overall knowledge of electric, hybrid electronics, and automobiles has greatly increased.
Cedarville College	I want to work as a program manager. I realized that I have potential as a leader and an engineer.	Learned lots about cars and building things.
	At first, it didn't matter where or what type of engineering I got into, but I know that the automotive industry (is the one).	It really gave me opportunity to work with a team of engineers. Plus the excellent hands-on experience.

EXHIBIT A-1
Student Survey Responses (Page 7 of 27)

School	In What Ways Has Participating in This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
Concordia University	No response	More practical knowledge. Learned the importance of effective teamwork and project management.
	Realized that entering the workforce is an important priority so as to implement solutions to real world problems.	No response.
	Hasn't.	Teamwork. Problem solving. Pressure to meet deadlines.
	It is plain to see that this is the car of the future, and I would like to be a part of this endeavor.	Being an electrical student, it has helped me to understand the operation of a motor vehicle.
	Created an interest in the automotive industry.	Real world experience.
GMI	Has not.	Project management. Fabrication skills. Used new/cutting-edge technologies.
	None, no real changes.	A lot of design and hands-on experience Contacts with members of industry.
	Possible job potential/interest in EV or HEV field.	Team building - learning about ME and EE relationships.
	It has helped open my eyes to new occupations and events in industry.	I learned a tremendous amount through hands-on work with upperclassmen.
U.S. Naval Academy	None.	Management ruled, what works best and what doesn't work in getting people to work.
	More information.	A chance to see/make the automotive industry move onward toward a more competitive/cleaner future.

EXHIBIT A-1
Student Survey Responses (Page 8 of 27)

School	In What Ways Has Participating In This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
U.S. Naval Academy (continued)	It has helped me to appreciate the value of working on a project with direct public application and public value.	I got to apply my "book" knowledge to a real-world problem. This helped me to get a real-world feel for what engineering is like.
	Working with the HEV has brought out my desire to work on automobiles and in the automotive industry.	I have learned about the many processes Involved in designing a piece for the HEV.
	I had thought about wanting to work in the car industry after my Navy commitment and this competition strengthened these beliefs.	It's given me a lot of insight into the "Detroit World" as well as meet a lot of people that are interested in the things that I am.
	In no way really.	I've learned much more about EVs and HEVs. I now know the different kinds of HEVs, more about alternative fuels, and lots more about how the different components of an HEV work together to make the vehicle work.
	Not at all.	Learned team cooperation, presentation skills, and working under the gun.
Pennsylvania State University	Realism.	Knowledge.
	Has increased my confidence in my abilities to be part of a team that can create a competitive vehicle. Our exposure to industry will increase job marketability.	Again, coming from a theoretically oriented university it is good to have the opportunity to experience going beyond theory and making a selected group of peers work in a complete vehicle package. The experience of supplier issues cannot be simulated in the classroom.
	--	I have learned team cooperation skills and that it takes a lot more time to do something like this than one would think.
	Helped define my research project and area of interest in industry.	Practical appreciation of vehicle packaging and design. Real experience with drive optimization.

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Student Survey Responses (Page 9 of 27)

School	In What Ways Has Participating In This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
Texas A&M University	I realized the importance of engineering societies and their shared information.	I was introduced to a lot of mechanical engineering problems, and I learned a lot of basic engineering.
	The project has not necessarily changed my goals, but I have come to the realization that I need to learn more about electronic controls.	Learned a great deal about working with others and dealing with those in industry.
	None, I had already planned to research and develop hybrids.	Gained practical experience in this(ese) field(s): electrical/electric power, CNG troubleshooting, energy management for hybrids.
	It has provided me a chance to see what goes into the design of a complicated product. This has given me a desire to grow toward a leadership role.	It has given me a great deal of experience that I would not have otherwise. I feel it has made me a better engineer and a better person in general.
	Made me not want to be involved in parts of ANL and NREL because of poor organization and bad attitudes.	Developed high degree of understanding of hybrid control philosophy, team leadership, and management and project organization skills.
Texas Tech University	Practical experience.	--
	Future goals remain unchanged.	The program has given me a good hands-on experience and an opportunity to experiment and understand HEV new technologies.
	Helped to define the kind of work (systems engineering) I want to do.	Great opportunity to get hands-on experience with some of the classroom theory, and to be on a multidisciplinary team.
	Might want to pursue some involvement with automotive industry.	Teamwork skills, dealing with people and communication, work under pressure.
	Raised expectations of future endeavors.	Leadership. Expertise.
	I have a greater desire to learn and help in the future design of our country's transportation.	I feel I've learned to use my interpersonal skills and technical application of my college education.

EXHIBIT A-1
Student Survey Responses (Page 10 of 27)

School	In What Ways Has Participating in This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
Texas Tech University (continued)	Emphasis on good planning and implementation. Keeping records. Test your prototypes thoroughly.	Learned to work in group situations. Developed the ability to brainstorm over the phone with previously unknown engineers from various companies.
University of Alberta	Involvement in future projects are in mind for the future.	Knowledge Connections Experience
	Opened opportunities in the auto industry.	Great experience with managing an entire project. Learning about the design of both mechanical and electrical components and the integration of the two.
	It has encouraged me to get more sleep. Seriously, it has encouraged me to go in to design.	Potential employees.
University of Connecticut	Did not alter.	Real "hands-on" work. Teamwork/team leadership.
	Reinforced my appreciation I have of working in the auto industry (specifically Chrysler). Helped me realize how many facets within the automotive engineering field there are.	Learned how many things are involved in understanding such a project. How people work together as a team has a large impact on how well the project progresses.
	It hasn't.	Course credit for graduation. Increased awareness on the workings of an automobile.
Univ of Illinois, Chicago	It has greatly increased my desire to work in the automotive industry. I have always dreamed of designing and fabricating my own vehicle and I feel that I am one step closer now.	I have learned more about structure integrity, engine control strategy, and electronics than my classes ever could.
University of Florida	My career goals were set.	Built teamwork skills, adjust to changing technology, applied theory to reality.
	I have become more interested in the automotive industry, particularly in the construction of tomorrow's hybrid vehicles.	I have actually constructed something from design to finished product.
	Has shown both positive and negative aspects of dealing with original designs and with industry.	Have learned practical skills in industry and have developed team skills.

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Student Survey Responses (Page 11 of 27)

School	In What Ways Has Participating in This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
University of Florida (continued)	It has diversified my education experience.	I learned some electrical stuff.
	None.	This project has united my friends and showed us that the practicality of fabrication is the dominant factor in automobile design.
	--	I learned an incredible amount about engines, catalytic converters and teamwork.
	None.	Great hands-on experience! Learned that nothing works right the first, second, . . . time but not to give up.
	Has broadened my career goals from only defense-related employment.	Improved teamworking and hands-on experience. Also, applications of the principles will aid in the classroom later.
	Too many to explain. Professionalism, design, teamwork.	--
University of Maryland	I want to come back for another competition.	Hands-on experience and working with a team.
	--	This is the first opportunity in school to gain real-world experience without loosing a job.
	Practical experience. Contacts with industry. Enhanced teamwork experience.	Same as question 3 plus: improved time considerations for projects; and the thrill of competing.
	Allows students practical engineering skills.	--
	--	Business contacts, technological awareness, managerial skills, personnel skills.
	I've become more determined to be employed in the car industry.	Gained hands-on experience.
	I always wanted to work in auto industry.	Practical knowledge.
	--	More practical knowledge, teamwork experience.

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Student Survey Responses (Page 12 of 27)

School	In What Ways Has Participating In This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
University of Maryland (continued)	With the people and experiences that I've encountered, I find myself excited about the prospects of working in the automotive industry.	I've learned a tremendous amount about the organization skills necessary and the motivational skills I will use in the future. I now have a better appreciation for the magnitude of the project.
	I really want to work in the automotive field.	Hands-on and practical experience.
	--	Learned more about hybrids.
	I have become much more interested in working on alternative fuel technologies.	I have gained hands-on experience with programmable logic controllers and learned some of the challenges facing the automotive industry in the future.
	It has not.	What's on paper does not always work in the real world.
	Raised my interest in alternative fuel technology.	Communication skills with industry improved dramatically.
University of Michigan	I've gained experience and skills in how to work and manage a project as well as with other people.	I've gained more practical experience in automotive design. Tearing apart and building a Neon has taught me to appreciate systems engineering.
	--	Developed communication skills. Team work Learned how all of the vehicle subsystems work.
	I know that the auto industry is too limiting to my creativity to be happy working in it.	I have improved in my project planning and execution skills. It is rewarding to see specs on paper turn into reality.
	I've deepened my interest in HEVs and realized that I want to work in the automotive industry.	Educated me about many parts of a car the I wouldn't normally see. Not only did I have to take the car apart, I also had to put it back together.
	It has made me more interested in the automotive industry.	I have learned more about cars in general and how things work together.
	It deepened my interest in the automotive industry.	I learned more about cars that I ever thought I'd want to know. I even started doing repairs on my own car.

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Student Survey Responses (Page 13 of 27)

School	In What Ways Has Participating In This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
University of Tennessee	I have become very interested in pursuing a hobby similar to the work I've done on this HEV.	I have learned a great deal about the automobile we used and have learned very much about practical engineering.
	I used to be a plant designer for about two years a long time ago. Since then, I planned to go back to plant business. However, after participating in the HEV project, I realized that all machines are alike and knowledge grows by creating any kind of machine.	I built my own philosophy. Through this project I learned that I can do anything I have the ability to do but I cannot do anything I do not have the ability to do. So I decided to have responsibility for whatever I can do and to trust my friends (teammates) for whatever I cannot do.
	It gave me engine controls experience which landed me a job.	I was the team captain, so I learned a lot about stress management and how to motivate people.
	It showed me that I would enjoy and be better at a job that involved hands-on, practical work (building things).	It helps build confidence both in one's engineering ability and communication/social abilities.
	I am now more aggressively seeking a job in the automotive field.	I gained considerable knowledge of general automotive aspects.
University of Western Ontario	It has given me many new experiences.	I have learned how to deal with real life experiences.
	Gave me an appreciation of dealing with people and working on practical problems and their solutions.	It was a very practical project that dealt with real-life situations and concerns.
	It has made me look at things in a more practical point of view instead of only theoretical.	I am learning more about cars; I was not familiar with them before.
	I now want to work in the automotive engineering field.	I have a new-found respect for engineers.
	Has not.	Learned about teamwork and red tape.
	To get more involved in hybrid vehicle.	Worked on engine and mechanical.
Virginia Polytechnic Institute and State University	(It has changed) my expectations of high technology applications under the pressures of endurance events.	Maturity in dealing with people in stressful situations.
	Reinforced desire to enter automotive field.	Tested engineering skills, made new friends/good interaction between EEs and MEs.

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Student Survey Responses (Page 14 of 27)

School	In What Ways Has Participating In This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
Virginia Polytechnic Institute and State University (continued)	It has made me want to seek more actively a position in the automotive industry.	It gave me very practical experience. I have done academic work and mechanic work up until this project. Now, I have experience doing both at the same time.
	It let me consider the automotive industry as a job option.	It has given me insight on practical uses of engineering.
Wayne State University	Has given me another career choice.	Learned to work with others.
	It enhanced my desire to work in the automotive industry.	Developed on-the-spot problem solving methods.
	Interest in HEVs.	Experience.
	More so, solidified my desire to work in the automotive field.	Have become more familiar with the engineering process and teamwork approach to practical engineering.
West Virginia University	Redirected toward the automotive industry.	Increased knowledge of EE field. Increased knowledge and experience in machining and welding.
Western Washington University	Better understanding of automobile industry.	Working as a team.
	More experience. Better jobs.	More experience.
	It has opened CNG-fueled vehicle systems up to me and how to optimize performance of them.	I have learned about working and being part of a team. I have also learned about retrofitting and building HEVs.
	--	I learned a lot about the car manufacturing and design modification processes.
	It has changed my view on HEV. EVs by themselves do not seem as a viable solution to problems facing the automotive industry, but HEVs offer a relatively easy transition into the next century.	Aside from the added knowledge gained from the vehicle built-up, my interaction skills have been improved.

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Student Survey Responses (Page 15 of 27)

School	In What Ways Has Participating in This Hybrid Electric Vehicle Project Changed Your Future Goals?	Describe How You Have Benefitted From the Car Building Program?
Western Washington University (continued)	My participation in this project has broadened my awareness of alternative powered vehicles as a viable means of solving our dependence on foreign oil and a reduction in emissions. Therefore, in the future, I will focus on getting these vehicles implemented into society.	I learned how to interface with an engineering team of this type, moreover, I learned how to implement an advanced prototype design in a short amount of time, and make it work.
	I see that CNG Technology and composites will be burgeoning fields in the future.	My packaging and engineering skills have improved and this has given me an improved vision of productive engineering.
	Has made me want to pursue natural gas vehicle technology extensively.	I have learned many aspects of what it takes to build a vehicle competitively. From engineering to cost accounting, to management, to leadership.

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Student Survey Responses (Page 16 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
California State University, Northridge	Gave me an opportunity to see how the auto industry functions and what it takes to become a member of a large auto-manufacturer.	None. The competition was organized very well.
	Test driving the HEV.	More competitors, racing.
	Seeing what other people did on their vehicle and participating in a large group project.	Better food and facilities, some large equipment that can't be brought like welder, press, benches. Very nice helpful people, appreciate the opportunities to Chrysler.
	It is too soon to make a judgment; there are still two days to go.	Require schools to come with a tested car, probably require a minimum of road-test hours.
	The feeling of seeing the finished product, a sense of accomplishment. Also, being able to see other ideas the students have, and the modifications made on each different vehicle type.	Weather conditions were unpredictable.
	Working on the car. The exposer to new technology.	More specifications. More social events to meet the other teams.
California State University, Chico	Range event.	A logical judging process.
	Our team.	People who make the decisions should be clearer and more in agreement. (consistent)
	Just the ability to come here and compete with other schools and see how we have done comparatively. Oh, yeah the free lunches too. Thanks.	A little more organization. Rules that reflect reality in the marketplace. Thanks.

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Student Survey Responses (Page 17 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
Cedarville College	Learning to work with people.	Meeting deadlines for the organizers, less politics during the competitions.
	The schools and the student participation.	I would like to see more competitions, like the HEV Challenge, where smaller Institutions would be able to continue to fund programs.
Concordia University	Practical learning experience, seeing the car running in events after all that work.	More involvement from school (ex. credits)
	The meeting of all the teams and team members.	--
	Meeting other students.	More time to complete the project, a better understanding from a corporate view of the time and effort required to complete the project. Possibly a budget limit so that all teams have access to equal resources (i.e., more money = better standing). Restrict use of stock engines (of course you'll meet emissions if you run stock).
	The experience and the energy of the competitive atmosphere.	The competition was well organized.
	Verifying quality of designs.	--
Ecole De Technologie Superieure	--	1 comp/2 years
GMI Engineering and Management Institute	Cooperating with industry on a practical project. Learning how to use current technology.	None.
	The intensity of the competition and the feeling of satisfaction once the job is done.	Stick to the rules. Dinner and breakfast provided. Job search/ resume party for seniors. More team mixers.
	Lunch.	Better organized, dinner and breakfast provided.
	The sensation of the Challenge.	Awareness of events and procedures was good but could be stressed a pinch more.

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Student Survey Responses (Page 18 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
United States Naval Academy	Seeing how others approach the same problem.	--
	Handling course.	Offer the course more assertively.
	Wearing eye protection all day!	None especially.
	I enjoyed the friendships made at the Challenge most. Everyone gets along and has a great time.	I thought the 95 Challenge was great except for scheduling.
	The real engineering "hands-on" type experience that I gained is otherwise lacking at the Naval Academy.	More events like the handling event that show the abilities of the cars as well as the feel between driver and machine.
	Getting to meet other engineering students from top engineering schools and being able to talk to them. Also the handling event was pretty cool.	The biggest improvements that seem to be made are better communications and start events on time. Too often the competitors had no idea what was going on and the events started late and the whole system got backed up.
	Designing the whole car from scratch.	Better scheduling - way too much waiting. Penalize teams for being late.
Penn State	Nothing in particular.	Consumer Reports.
	The competition in the Escort class conversions. The teams were very courteous and it was nice to discuss the various solutions used by different groups given a common problem.	Rule the car on budget, or limit budget. The results from Wisconsin's $242,000.00 budget is clear and expected, as this team has a budget that is approximately 10 times larger than Penn State. Though we are pleased to have placed 2nd in design despite this fact.
	The feeling of unity the Escort teams had. Everyone was cool. Helped each other out.	Five minute limit on pit-stop from Escort range event. Takes that long just to stop and get out of the car.
	The events.	--

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Student Survey Responses (Page 19 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See In Future Student Competitions?
Texas A&M University	Driving the car on the Chrysler test track. Free lunches were great!	More fun driving. When we called for ruled information, they did not know the answers. Don't send people to participate/officiate that don't want to be here. Some of the officials lacked an encouraging attitude and treated the car like a production unit instead of a prototype.
	Driving tests. Lunches. Observing other schools at work.	More enthusiastic judges. More definitive answers from officials when asked about the rules of the contest.
	Events. Seeing what other schools developed.	Clearer rules. Judges with more encouraging attitudes. Some acted like our work was trash, and we were under time and money constraints. If they messed something up, they did not apologize.
	Witnessing the project go from paper to parts to a working machine is a very gratifying feeling that is rare in University education.	Judges in consumer acceptability should be easier on cars unless the test could be moved to last. Teams should not be penalized because the judge damaged their vehicle.

EXHIBIT A-1
Student Survey Responses (Page 20 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
Texas A&M University (continued)	Parts where we drive the car and when we make the car work.	More driving events. No event-supplied kWhr meters (it burned our car many times). Judges ought to apologize when they hurt our cars. In an example, during the underbody inspection AFTER we passed the clearance, the main battery cables were ripped going up the underbody ramp - with no apologies from the judge. Judges would be better if they tried to HELP teams rather than "rip" them. We put lots of money and effort into our HEV -more than any of the race sponsors (except Dodge) provided. We build a car and teach Argonne and NREL our hybrid strategies and then provide valuable data. I feel used by ANL and NREL by providing presentations, data, and technologies only to be treated badly and insultingly talked down to. I feel we should have been treated like guests and our technology respected. I know many other schools feel this way but probably deny letting their feelings known out of respect of the event and ANL, NREL. Many of the race organizers were helpful, including Nicole, Lassie, Warren Salt, Bill Croll, and the nice guys from Cruising equipment with sorry equipment. Because of the poor organization (i.e., the underbody ramp that required higher-than-spec ground clearance) and no apologies for sometimes critical mistakes (battery cable severed), I will not personally participate in a similar event.
Texas Tech University	The competition.	Follow the rules.
	Teamwork and the opportunity to gain experience by working hands-on with this new technology.	More universities involved.

EXHIBIT A-1
Student Survey Responses (Page 21 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
Texas Tech University (continued)	The experience. Design implementation of a large project. A great educational experience.	- Better definition of rules and adherence to some. We suffered tremendously all year over the ambiguity of the HVAC rules and could never get a clear answer. AT the last minute, we added the ZEV HVAC, and it cost us our emissions points because we couldn't get the car in for emissions testing prior to completion. - Feedback. We can't improve on technical report and design review when we don't know what our short-comings are. We followed the printed materials to the letter. - Some recognition for the reliability of the vehicles. We passed qualifying and technical inspection first (and were here on time) because of our diligent efforts before the competition. It is frustrating that several of the cars with extreme problems are pulling ahead in points (and are inoperable most of the time).
	Companionship and working with others. The actual completion.	Better scheduling. More specific rules with less assumptions and bending of them.
	Competing against my peers.	More performance-oriented events.
	Building the car, setting a goal, and achieving it.	I feel the rules laid out in the beginning should be adhered to and not be "wishy-washy."
	Being able to see your part of the project perform in a real world situation!	Strict adhesion to qualifying rules and regulations. Better coordination in qualifying events.
University of Alberta	Competition and meeting other teams.	--
	Sharing ideas with other teams.	This competition was very well organized. Recommend that teams have better description of events.
	The other teams!	More consistent rules.

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Student Survey Responses (Page 22 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
University of Connecticut	The competition between the schools.	A top-end budget/budget cap.
	The competition and especially Chrysler's support throughout the event.	Waterproof and larger pit areas. More frequent competition update pamphlets.
	The technical, financial, and component support of the Chrysler corporation, in addition to being able to work on the Neon.	The teams should get better explanations of scoring. Rules should be changed less, and the overall organization could be improved.
University of Illinois, Chicago	Seeing all the different ideas and meeting all the different people.	Better organization and more time between charging dependant events.
University of Florida	Completion of a working vehicle. Watching hard work pay-off in a tangible product.	See qualifications adhered to more strictly. Post event scores after each event. Require sponsor to support on-site.
	Moral and team spirit fostered between competitive student team organizations.	Increased sponsor involvement at the local level.
	The competition.	I would like to see another hybrid electric vehicle challenge.
	Seeing personal ideas, concepts come together to form a working product.	More schools!
	Competing at the event and working with great people.	Definitely more rigid enforcing of rules and clarity in defining the rules. Many rules ere compromised and some were not clear enough to trust. Also, rule changing in the middle of the completion is unacceptable.
	Making the most of a limited power source and creating a viable alternative to the fossil fuel vehicles.	A consistent application of the rules to each team for all events would make the scoring a better representation of each HEV's achievements.
	Free lunch!	Increased clarity in the application of competition rules.
	The banquet, the food, and Nicole LeBlanc!	Stricter adherence to the established rules.

EXHIBIT A-1
Student Survey Responses (Page 23 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
University of Florida (continued)	Facilities tour. Acceleration events.	Fairness in granting petitions to all teams could be improved.
University of Maryland	Free food.	- A lounge we can sleep in. - Rides or driving of exotic vehicles on display. - Pits staying open later.
	Team work/group dynamics practice.	- Some sincerity from the students toward emission control. - If you allow alcohol fuels, aldehydes should be measured.
	The bitter struggle and adrenalin.	Announce meeting times AHEAD of time.
		Better announcements of meeting times/event organizations over the P.A. system, with plenty of advance warnings.
	Building the car from your design.	--
	Teamwork.	Shorten speeches and awards presentations.
	Meeting the people responsible for the event and prospective employers on "equal" ground.	More emphasis on emissions, more cooperation and technology exchange from the national labs and companies.
	The nights.	Better, well-balanced lunches.
	--	Let us sleep more. Start on time.
	The opportunity to share knowledge and experience with students and professionals. Teamwork.	More organization. More information on career opportunities.
	Hands-on experience. Team work.	--
University of Michigan	The various events.	A more wide range of event locations.
	The beginning (for all the hope and promise) and the end (for its end result). But the weeks prior to the event were hell and fun at the same time.	--

EXHIBIT A-1
Student Survey Responses (Page 24 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See In Future Student Competitions?
University of Michigan (continued)	Practical hands-on engineering experience. Meeting other schools and hearing about their vehicle's systems and configurations.	--
	It was very nice to see teams working to help each other instead of being in tight completion.	I would like to see much more technical mentorship from sponsors and organizers early on in the team's project. This would give a better initial directions, raising yields on the final project.
	--	Instead of one big meeting for all classes, have individual class (Neon, Escort, Saturn) meetings every morning to remind teams of the days events and any changes that have occurred. That way, all teams will be working toward the same goal.
	I liked meeting all of the students from other schools.	None.
	I enjoyed the camaraderie between the teams.	I wish there was one race type event to push the cars their fastest, even if it wasn't for points.
University of Tennessee	Seeing an idea materialize into a working system and watching it compete with others who have built a device to do the same thing (sometimes they solved the problem in a manner I had never thought of).	Do not change requirements after the design process has started. When rules change quickly, it can be expensive and time consuming for schools to back-track and redo a design. This can and has resulted in cars arriving to a competition in a less-than-finished state.
	There are so many ways to build an HEV, but one team can only try a single way to build it. So, once we decide the way, we just stick to it and complete building it. Then, we debug each faulty part of it. Fortunately, our facility advisor trusted us and let us build the car in this way. As a result, the parts I made worked perfectly in competition, and I could gain self-confidence for it.	From a standpoint of the battery group in my team, I saw all groups heavily relied upon APU rather than battery power. The reason was the battery itself has not been well developed to support more traction power. In the future, I would like to see more battery power support rather than APU support in HEV.
	For me, it was winning the emissions event and making our vehicle pass ULEV standards.	More monetary support and clearer, more consistent (non-volatile) rules.

EXHIBIT A-1

Student Survey Responses (Page 25 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
University of Tennessee (continued)	Working as a team with different divisions of engineering (electrical and mechanical for instance).	Leave blocks in the schedule that late (last minute) quality events can be easily scheduled for teams having troubles. The organizers and workers did a very good job of helping teams when they could. It just might make it easier to make schedule changes if the original schedule was slightly more flexible. The catch to all this is the completion itself does not need to be any longer (timewise).
	Winning the emissions test. I was a member of our emissions group. It was very satisfying to see the results of a year's hard work.	Realizing that the organization of such and event is tremendous, it would be extremely helpful if a set of rules was established initially and not changed.
University of Western Ontario	The teamwork and sharing of tools and ideas with the other team members.	I think that rules and regulations should be followed more closely.
	The friendships formed and camaraderie among the different teams of the HEV Challenge.	Consistency in setting and enforcing deadlines for events that have points associated with them.
	The teamwork. To see all different types of decisions.	Hold it in a less privatized place. The organizers should be on the "same page"; they told you different things.
	The friendship and camaraderie between the competitors.	Too many exceptions to rules. Not enough explanation of point distribution.
	Being able to exchange ideas and information with other people/schools.	Not longer than one week.
	I think it was all good.	--
Virginia Polytechnic Institute and State University	The outdoor HEV range, ZEV range, and handling.	Better access to the charging station.
	Meeting other competitors, sharing ideas/information.	Road race/rally.
	The best part was that we all started with exactly the same car. It was very interesting to see what decisions other teams had made concerning placement of vital components.	More charging time for series cars. Our car was made with more of a commuter viewpoint, and long times without charging put us at a disadvantage.
	Teamwork.	More charging time for batteries.

EXHIBIT A-1
Student Survey Responses (Page 26 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
Virginia Polytechnic Institute and State University (continued)	Chrysler Technology Center.	More charging.
Wayne State University	Being able to prove our car worked. Competing with other schools.	More emphasis in scoring dynamic events. Earlier finalization of the rules. Required equipment provided by competition should be sent out earlier.
	The dynamic events.	Have less emphasis on the Mickey Mouse events such as the report, consumer acceptability, and design review and stress more on the performance (real engineering) events!
	Dynamic and emission event	Reduce the Mickey Mouse point.
	Meeting fellow engineers from across North America.	Less emphasis on non-performance events. There seemed to be a bias toward series configured vehicles (Escort class).
Western Washington University	Meeting other teams; seeing their designs.	Tighter rules.
	Better stress management.	Shorter event.
	The design review and performance tests, because they test the reasons why things were done and the applications of those ideas.	More performance-based events.
	Getting a chance to put our work to the test and getting some sort of tangible reward for the time that was spent on this project.	More continuity in rules and regulations. Don't change and re-change things at the last minute. Keep competitors better informed with regard to rules changes and scores.

EXHIBIT A-1

Student Survey Responses (Page 27 of 27)

School	What Do You Think Was the Best Part of the HEV Challenge?	What Changes or Improvements Would You Like to See in Future Student Competitions?
Western Washington University (continued)	The interaction at the Chrysler Technology Center.	More objective testing and better food.
	Being part of the competition amongst the very best universities across North America.	More objective, dynamic vehicle testing.
	Meeting other competitors and seeing how their vehicles are put together.	A clearer distinction of what is necessary to qualify and a broader window to do that. More time for charging.
	Having facilities to fully test the design of our vehicle.	More of a food variety. Shorter.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 1 of 14)

School	Subjects Taught by Faculty Advisor	Number of Students		Vehicle Type	Resources ($)		
		At Event	On Project		School Contribution	Private Donations	Total Cost
California State University - Chico	Mechanical Design, Dynamics, Materials	4	15	Saturn	$20,000	$200,000	$220,000
California State University - Fresno	Automotive Technology	14	30	Saturn	$15,000	$100,000	$115,000
Cedarville College	Intro to Engineering, Manufacturing, Engineering Economy	20	65	Saturn	$30,000	$40,000	$70,000
Concordia University	Thermodynamics, Internal Combustion Engines	10	17	Neon	$5,000	$15,000	$20,000
Ecole de Technologie Superieure	Machine Design, Composites, Design	12	15	Saturn	$2000	$20,000	$22,000
Illinois Institute of Technology	Thermodynamics, Heat Transfer, Invention	6	10	Saturn	$500	$10,000	$10,500
Texas A&M University	Electrical, Engineering, Power Electronics	80	80	Neon	$100,000	$25,000	$125,000
Texas Tech University	Thermodynamics, Design I, Design II, Thermal Systems Lab	14	20	Neon	$10,000	$60,000	$70,000
United States Naval Academy	Thermodynamics, Heat Transfer, Internal Combustion Engines, HEV Design	9	24	Escort	$12,000	$8,000	$20,000

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 2 of 14)

School	Subjects Taught by Faculty Advisor	Number of Students		Vehicle Type	Resources ($)		
		At Event	On Project		School Contribution	Private Donations	Total Cost
University of Alberta	Thermodynamics, Heat Transfer, Internal Combustion Engines, HVAC, Statics, Dynamics	15	40	Escort	$16,500	$41,000	$57,500
University of California - Irvine	Electric Power Systems	6	15	Escort	$0	$42,000	$42,000
University of Connecticut	Mechanical Measurements, Vibration, Linear Systems	5	15	Neon	$2,000	$28,000	$30,000
University of Florida	Graphics, Kinematics, Dynamics, Design	20	50	Neon	$12,000	$110,000	$122,000
University of Maryland	Mechanical Engineering	25	40	Saturn	$25,000	$25,000	$50,000
University of Tennessee	Electrical Engineering, Controls, Computers	11	15	Neon			
University of Texas - Austin	Thermodynamics, Engines, Combustion	6	8	Saturn	$500	$30,000	$30,500
University of Western Ontario	Mechanics of Solids and Mechanical Design	10	12	Saturn	$0	$25,000	$25,000
University of Wisconsin - Madison	Design, Mechanical Engineer	15	50	Escort			
Virginia Polytechnic Institute and State University	Senior Design, Heat Transfer	15	60	Neon	$15,000	$0	$15,000

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 3 of 14)

School	Subjects Taught by Faculty Advisor	Number of Students		Vehicle Type	Resources ($)		
		At Event	On Project		School Contribution	Private Donations	Total Cost
Wayne State University	Power Electronics, Electromechanics, Power Systems	10	15	Escort	$2,000	$8,000	$10,000
West Virginia University	Senior Engineering Design, Numerical Analysis	4	10	Escort	$10,000	$10,000	$20,000
Western Washington University	Vehicle Design, Automotive Electrical Systems	9	15	Neon	$24,000	$30,000	$54,000
Wentworth Institute of Technology	Manufacturing Processes I, Printed Circuit Board Fabrication	9	18	Saturn	$18,000	$60,000	$78,000
Average		14.1	27.8		$15,214	$42,238	$57,452

Schools not listed did not answer the questions in this table.

EXHIBIT B-1

Faculty Advisor Survey Responses (Page 4 of 14)

School	What Percent of Your Students Received Credit for Their Work on the Student Vehicle?	Time Invested in Car		Would You Participate in Another Student Competition?	What Did You Like Best About the 1995 HEV Challenge?
		Hours/ Week	# of Weeks		
California State University - Chico	90%	2	20	Yes, a great opportunity for the students to get hands-on experience on a real world problem and carry it to conclusion.	The opportunity to see the different technologies used for solving the same problem.
California State University - Fresno	60%	20	108	Yes, excellent experience.	Real life experience preparation for students future jobs in industry. Very motivated to succeed at complicated research and design projects.

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 5 of 14)

School	What Percent of Your Students Received Credit for Their Work on the Student Vehicle?	Time Invested in Car		Would You Participate in Another Student Competition?	What Did You Like Best About the 1995 HEV Challenge?
		Hours/ Week	# of Weeks		
Cedarville College	20%	10	40	Definitely yes (we're in the Propane Challenge). Our motivation for involvement is to provide the students with a real life development project experience. An external (non-academic, non-hypothetical) competition of this scale provides the elements we think are valuable - team involvement, interaction of multiple "sub-teams" with overlapping responsibilities, accountability, real cost & schedule constraints, interface with vendors, PR, communication of results, professional society involvement, design problems and alternative evaluation, etc.	Communication at the competition was greatly improved over '94 - '94 had an unfortunate adversarial overtone; the organizers needed help but won't accept it from the advisors, etc. Results weren't posted - everything got very tense and hostile. The message was received and '95 was much different, a real air of cooperation prevailed. I rehash '94 only as an example of how important "attitude" and "communication" (especially a running status of results) are to a group of emotionally charged students, many of whom haven't slept in the past week. There were some excellent professional interactions - tour of the tech. center, Eaton speaking, various OEM's in the pits, etc. - makes the students think what they're doing is important.
Concordia University	15%	3	30	Yes, it is educative for the students and is improving the reputation of the University.	Well organized, good student accommodation, good information. A great event.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 6 of 14)

School	What Percent of Your Students Received Credit for Their Work on the Student Vehicle?	Time Invested In Car		Would You Participate In Another Student Competition?	What Did You Like Best About the 1995 HEV Challenge?
		Hours/ Week	# of Weeks		
Ecole de Technologie Superieure	N/A	1	20	Yes.	Organization.
Illinois Institute of Technology	50%	2	50	Sure. It's quite stimulating. The students have fun.	Very well organized compared to other student competitions. Chrysler, a gracious host, beloved superbly. Great team spirit.
Texas A&M University	10%	20	40	No, it served its purpose.	It was an opportunity to attract student and public attention to our EV and HEV research and education program.
Texas Tech University	90%	6	36	Yes, valuable experience for students.	Student participation.
United States Naval Academy	100%	15	40	Yes, this is an excellent opportunity for students to practice engineering; projects such as this are essential in the development of engineers.	Chrysler obviously put in a greater amount of money and time than did Saturn. Ford was still the most organized though. ASK PHIL ABOUT THIS???
University of Alberta	0%	8	38	Yes, a great way to build teamwork, entrepreneur skills, and see direct application of classroom theory.	Meeting and working with all the other teams and the organizers. The exchanging of ideas, giving help to one another was a great experience for all.
University of California - Irvine	87%	6	33	No, the national student competitions do not fit our quarter calendar. We are at a serious disadvantage by starting late and still facing finals when the competition occurs.	Well organized, cash donation from Chrysler.

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 7 of 14)

School	What Percent of Your Students Received Credit for Their Work on the Student Vehicle?	Time Invested In Car		Would You Participate In Another Student Competition?	What Did You Like Best About the 1995 HEV Challenge?
		Hours/ Week	# of Weeks		
University of Connecticut	80%	6	70	I would not have participated at all, but was asked to do so by my dept.. I feel my time would have been better spent on my own research.	Well, it was fun. Chrysler was an excellent host. The chance to work with good students and sometimes industry was rewarding.
University of Florida	80%	5	45	Yes.	Near "real world" learning experience for students. Good "hands-on" work.
University of Maryland	100%	25	52	Yes.	(The event) was better organized than some in the past.
University of Tennessee	100%	4	25	Yes, very high value to students.	Flexibility of APU/EM combination.
University of Texas - Austin	0%	1	36	Yes, valuable educational experience for the students.	Interactions with other teams, judges, and auto industry.
University of Western Ontario	N/A	15	10	Yes, unfortunately the HEV Challenge will not take place next year.	It was a very well organized competition. Good lunch was provided.
University of Wisconsin - Madison	25%	15	40	Yes, good training and experience for students.	Competition, student involvement and excitement, and the students learning.
Virginia Polytechnic Institute and State University	50%	20	60	Yes, FutureCar. Excellent engineering education experience.	The students (plus my own) learning. Competing with other universities. The organization and the organizers. The CTC was awesome too!
Wayne State University	0%	30	40	Yes, valuable educational and research experience.	Very well organized, performance events were very well thought out.

EXHIBIT B-1

Faculty Advisor Survey Responses (Page 8 of 14)

School	What Percent of Your Students Received Credit for Their Work on the Student Vehicle?	Time Invested in Car		Would You Participate in Another Student Competition?	What Did You Like Best About the 1995 HEV Challenge?
		Hours/ Week	# of Weeks		
West Virginia University	25%	40	40	Yes.	Well run event. Range, acceleration, and emissions events were well thought out to show the benefits of HEVs. (Improved energy usage, lower tailpipe emissions).
Western Washington University	90%	5	36	Yes, I feel that hands-on projects lead to excellent understanding of the necessary compromises when reducing theory to practice. Students experience first hand the effort needed to meet real deadlines.	The event itself in Michigan.
Wentworth Institute of Technology	0%	20	20	Yes, student competitions like the HEV Challenge help engineering students crosstrain in other fields besides their own.	Meeting, talking, and competing with other engineering colleges.
Averages	51%	12.1	40.0		

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 9 of 14)

School	What Improvements Would You Like to See In Future Student Competitions?	What, If Any Follow-on Research From Government and Private Industry Sources Has Developed From Your Student Competition Participation?	Do you Feel That Any Interaction Occurred Between Your Team and OEMs or Suppliers That Could Lead to Technology Transfer?
California State University - Chico	More flexibility in use of pits. No restrictions on pit time in range event. Date is too close to exam week. We would prefer a later date (end of June). Cameras should be allowed at event.	None so far.	Yes, (1)Motor manufacturers (2)Battery manufacturer, particularly in packaging the batteries.
California State University - Fresno	Hold a faculty advisor orientation/event discussion meeting early in competition.	The CSUF Saturn HEV team has had numerous follow-on research, government contact, private industry, and further competition planning since their big win in Detroit.	Continual involvement with: • Alternative Fuel Representatives • Environmental Authorities • Engine and Vehicle Research Consultants

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 10 of 14)

School	What Improvements Would You Like to See In Future Student Competitions?	What, If Any Follow-on Research From Government and Private Industry Sources Has Developed From Your Student Competition Participation?	Do you Feel That Any Interaction Occurred Between Your Team and OEMs or Suppliers That Could Lead to Technology Transfer?
Cedarville College	Rules are always a problem. We all want these to be "all year" not "last two weeks" projects. Late and changing rules delay everything. Right now (December 95) we are still waiting for the first release of the Propane Challenge rules. Shorter events would probably be better -- a week is too long and costly. It also promoted "finishing it" after you arrive. It would be nice to have vehicle cost considered as more of a factor -- to keep it within a reasonable range and the field relatively level. Requirements that stimulated more participation - multiple drivers for example.	Cedarville is a "teaching", not a research institution so our motivations are different. We recognize research as a noble objective but hope that "engineering experience" would also be considered. Our competitions last year resulted in "relationship" with more than 50 different government labs and industries -- as material and service donors. Approximately a third of them lead to something further like equipment donation, internships, jobs or special "display" opportunities. This country is being out-engineered, not out-researched.	From us to them -- technology no -- good young engineers, yes. Their benefit is to expose this generation to various emerging technologies and real development situations.
Concordia University	I think that the competition's organization did mature. More emphasis should be put on the merit for low cost of the project. Universities with more money have a much better chance to win.	We are engaged with the City of Montreal in evaluating our Ford Escort HEV in normal city-use conditions. Our car has been given to the city for one year. The students are maintaining it and writing reports to Transport Canada.	Not yet. We are in the FutureCar competition which will bring more interaction.
Ecole de Technologie Superieure	N/A	N/A	N/A

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 11 of 14)

School	What Improvements Would You Like to See In Future Student Competitions?	What, If Any Follow-on Research From Government and Private Industry Sources Has Developed From Your Student Competition Participation?	Do you Feel That Any Interaction Occurred Between Your Team and OEMs or Suppliers That Could Lead to Technology Transfer?
Illinois Institute of Technology	1. Make it shorter - a week is too long. 2. Provide more flexibility in qualifying events. My students were upset because even though they participated in the events and did very well, they got no points because qualifying had been closed days before. 3. Judges are fooled by the appearance of hi-tech but give no points for design simplicity and integration. 4. Cost-effectiveness should earn points.	Maybe something from Ford.	No, engineers don't usually approach these competitions with a fully open mind, (much less managers).
Texas A&M University	More funding from DOE.	Our vehicle will be used as a mobile testbed for our HEV research.	No
Texas Tech. University	1. Clearly define technical requests that are logical and do not change. 2. Enforce competition rules without compromising.	N/A	N/A
United States Naval Academy	1. Put cost-effectiveness back in! No engineer is allowed to design without cost restraints! 2. Make the safety pre-inspection worth some competition points. 3. Give bonus points to the first three qualifiers to help speed up qualifying!	N/A	N/A

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 12 of 14)

School	What Improvements Would You Like to See In Future Student Competitions?	What, If Any Follow-on Research From Government and Private Industry Sources Has Developed From Your Student Competition Participation?	Do you Feel That Any Interaction Occurred Between Your Team and OEMs or Suppliers That Could Lead to Technology Transfer?
University of Alberta	Major concern was delays in rules and changes in rules during the year. Certainly some minor rules were not enforced (e.g., SAE membership). The event ran quite well, we fortunately did not have major problems during the event but if we had, the limiting working hours would have made things more difficult. The Detroit Edison people were a great help with charging problems. The PR session could have spent more time on the students.	• A study of engine performance and emissions using 4 different natural gas conversion kits • Our first HEV is in "daily" service. A major sponsor is using the vehicle for energy studies of HEVs. This is a sponsored MS thesis study. • Extensions of this latter study are under negotiation potentially using advanced batteries.	Not directly. However, six of the lead students are now employed by OEMs, some directly on HEV and EV projects. Indirectly, technology transfer is taking place.
University of California - Irvine	Timing (calendar).	No on-campus research but job offers to students have resulted.	Several exploratory contacts were made, no results.
University of Connecticut	Continuity of Funding! The competition was well managed. Our only real complaints concerned the computer BBS for technical questions -- would much rather phone a human	The project continues here on a small scale with industrial sponsorship. Other contacts may pay off in the long run.	Yes -- we have a much better idea of the level of technology used in the automotive industry and its goals.
University of Florida	Get rules out early and DON'T CHANGE THEM.	N/A	N/A
University of Maryland	Stick to the rules.	A contract with NREL and Westinghouse.	Perhaps our control strategy.

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 13 of 14)

School	What Improvements Would You Like to See In Future Student Competitions?	What, If Any Follow-on Research From Government and Private Industry Sources Has Developed From Your Student Competition Participation?	Do you Feel That Any Interaction Occurred Between Your Team and OEMs or Suppliers That Could Lead to Technology Transfer?
University of Tennessee	Provide donuts and coffee - the events start too early to get breakfast. Be more realistic about the schedule. Most events seemed to start 30-45 minutes late. The volunteers need to be better informed, especially at the info/registration desk.	N/A	N/A
University of Texas - Austin	1. More flexibility in event scheduling so that schools that have to make a repair are less likely to get zero points for one or more events. 2. More in-depth emissions tests/analyses.	Due to the NGV Challenge, I have received funding for two large NGV research projects.	We got first place in both the written report and oral presentation. Thus, I think the OEMs found our concept to be sound, practical, and useful. In turn, this could lead to tech. transfer.
University of Western Ontario	• Site should have less security and allow participant to have more freedom of movement and picture taking. • This kind of event should continue in the future. Too bad that the Saturn HEV Challenge will not occur in 1996.	N/A	N/A
University of Wisconsin - Madison	Shorten the length of stay for the HEV Challenge. Our budget is not that large.	None.	I think interaction has been poor, with the exception of a few individuals for the car companies who appear to be interested in what our students are doing.
Virginia Polytechnic Institute and State University	Can't be too clear on the rules, and how they will be enforced. Improved access to charging, refueling.	None yet. Still hopeful.	Hard to say - not exactly yet, but may happen.

Schools not listed did not answer the questions in this table.

EXHIBIT B-1
Faculty Advisor Survey Responses (Page 14 of 14)

School	What Improvements Would You Like to See in Future Student Competitions?	What, if Any Follow-on Research From Government and Private Industry Sources Has Developed From Your Student Competition Participation?	Do you Feel That Any Interaction Occurred Between Your Team and OEMs or Suppliers That Could Lead to Technology Transfer?
Wayne State University	Just ask Congress to continue HEV Challenge funding so these events can be continued. Also, do not allow the auto companies to include extraneous requirements such as natural gas engines and air conditioning. Concentrate on the hybrid powertrain issues. ??? ASK PHIL	We are working to get support. Unfortunately, DOE has earmarked all of its hybrid vehicle funding to two large contracts with Ford and GM.	At the moment practically all information flowed from suppliers into our efforts. The systems we developed may eventually be of interest to the auto manufacturers. In our case, we really did demonstrate what could be done with a hybrid-drive with a large increase in the efficiency of the stock 1.9 liter Ford engine.
West Virginia University	Penalties for unprepared vehicles arriving at the competition. Tighten up rules and interpretations somewhat (this has improved radically over the past three yrs.). Shorter competitions are essential.	N/A	N/A
Western Washington University			
Wentworth Institute of Technology	Improved organization.	Starting a Northeast regional training laboratory in Alternative Fuel Vehicles.	Yes, now working with Square D and Westinghouse on Main Power Disconnect Switch for EV use.

Schools not listed did not answer the questions in this table.

Building Technology, State, and Community Sector Program Mission

Q219. On page 334 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Detailed program-by-program analysis indicates that successfully achieving the program's goals by the year 2010 will result in total energy savings of from 2.9 to 4.9 quads, a decrease from projected energy use of up to 13% at the same time that households and commercial floorspace are projected to increase by over 17%. . . . Consumers will save up to $39 billion annually in reduced energy bills by 2010, . . and cumulatively they will save up to $700 billion through the year 2020. . . .Substantially less electric operating capacity will have to be constructed. Of the projected energy savings in 2010, nearly 70% will be savings in electricity. This is equivalent to not having to build over sixty-five 1,000 megawatt coal-fired plants over the next 15 years, an avoided capital expenditure of over $65 billion. Buildings-related atmospheric carbon emissions will be reduced from forecast levels by 60 to 100 million metric tons annually by 2010."

Q219a. Please provide detailed documentation of these claimed benefits.

A219a. The energy savings figures cited above are the total numbers for the entire Office of Building Technology, State, and Community Programs developed in the EERE Quality Metrics exercise conducted in support of the FY 1997 Budget Request. Detailed documentation of the program-by-program energy savings estimates is provided in the responses to Questions 19a (Solar Buildings Appliances R&D), 220a (Building Systems Design), 241a (Space Conditioning R&D), 251a (Materials and Structures R&D), 256a (Windows and Glazings R&D), 260a (Building Standards and Guidelines), 264a (Lighting and Appliance Standards). The higher energy savings estimate (4.9 quads) is the sum of all of the individual program-level energy savings estimates for the year 2010; the lower figure (2.9 quads) is from analysis conducted by the Office of Planning and Assessment (OPA) using a mathematical model of the U.S. energy system (IDEAS) as an integrating framework to eliminate double counting among both the sectors and individual programs. Projections of the number of households, commercial floor space, and baseline energy use are taken from the Energy Information Administration's *Annual Energy Outlook 1996*, Tables A4 and A5 (Reference Case). The $39 billion in consumer energy savings is calculated by multiplying the energy savings of 4.9 quads (above, disaggregated by fuel form) by energy price projections for 2010 from the *Annual Energy Outlook 1995* (the 1996 edition had not been released at the time the cost savings were compiled). Similarly, the $700 billion in cumulative savings through 2020 is derived by integrating the Quality Metrics estimates of energy cost savings for all years between 1997 and 2020; estimates of savings for intermediate years not specifically addressed in the Quality Metrics estimates were estimated by interpolation.

The *1996 Annual Energy Outlook* (Table A9) projects that net cumulative additions to electric generating capacity (including non-utility generation) through 2010 will be approximately 92 gigawatts. The *1996 Annual Energy Outlook* (Table A2) also projects that buildings will be responsible for 70% of the increase in electricity demand through 2010. The 4.9 quads of energy savings discussed above essentially holds building energy consumption constant through 2010, avoiding any increase in demand for electricity and avoiding the need for additional capacity to serve buildings. The avoided capacity addition is thus 70% of 92 GW about 65 GW (or about sixty-five 1,000 MW plants). Using a conservative capital cost estimate of $1,000 per kW, this translates to $65 billion in avoided investment.

Q219b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A219b. There are numerous barriers to improving energy efficiency in buildings. Building construction and product manufacturing firms are generally small companies that tend to resist change and invest little in R&D. Even large manufacturers of appliances and equipment have not often viewed energy-efficiency as a major concern. Reliable information on the performance and benefits of energy using equipment and energy-efficient buildings is often not readily available or easily understood by consumers. Purchasers of energy-using equipment are often not the ultimate owners, and thus tend to minimize first costs rather than life-cycle costs. Without specific actions to overcome these barriers, progress toward improving the energy efficiency of buildings would stagnate. Most of the progress to date in improving building energy efficiency can be traced to or was stimulated by DOE actions, including standards, labeling, and the development and introduction of new technologies, labeling and standards. The most prominent and successful new energy-efficient technologies for buildings in the marketplace today (low-E window coatings, solid-state ballasts, high-efficiency refrigerator compressors) were developed and/or commercialized with DOE assistance. There is little reason to believe that the future benefits claimed for the DOE program would be achieved in the absence of that program.

Building Systems Design

Q220. Page 344 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the Building Systems Design program "[a]t the proposed funding levels":

	2000	2010	2020
Total Primary Energy Displaced (Quadrillion Btu's)	**0.2**	**0.8**	**1.7**
Total Energy Cost Savings (Millions $ 1995)	**1,350**	**6,060**	**14,190**
Carbon Equivalent Emissions Reductions (MM Tons)	**4.2**	**16.4**	**35.3**

Q220a. Please provide detailed documentation of these claimed benefits.

A220a. All programs for which BTS is requesting funding have been assigned to one of nine planning units to simplify cross-sector comparisons and restrict to a manageable number the elements being evaluated. Benefits estimates appearing in the Budget Request are assessed at the planning unit level.

Building Systems Design consists of three planning units: Residential Buildings, Commercial Buildings, and Best Practices. The three planning units are comprised of the following programs:

- Residential Buildings Planning Unit
    - Building America
    - Residential Energy Efficiency Programs

- Commercial Buildings Planning Unit
    - Advanced Buildings for 2005
    - Rebuild America
    - Existing Buildings Energy Research
    - Affordable Homes for Low-Income Families

- Best Practices Planning Unit
    - Design for Best Practice: Energy Tools
    - Passive Solar
    - Indoor Air Quality
    - Outreach

The benefits are estimated at a program level and then aggregated to yield planning unit level benefits. Energy cost savings and carbon equivalent emissions reductions are computed from the energy savings. The primary energy savings benefits (in trillion Btus) for building Systems Design, by program are as follows:

Program	2000	2010	2020
Residential Buildings			
Building America	1	24	81
Residential Energy Efficiency Programs	0	4	19
Commercial Buildings			
Advanced Buildings for 2005	33	99	203
Rebuild America	96	288	576
Existing Buildings Energy Research	5	15	31
Affordable Homes for Low-Income Families	20	34	30
Best Practices			
Design for Best Practice: Energy Tools	39	141	313
Passive Solar	20	70	156
Indoor Air Quality	1	33	107
Outreach	12	70	138

Most of these programs target the building envelope, a whole building design approach, or the total building system, and are modeled as improvements to the building envelope. Envelope programs are characterized by a reduction in space conditioning load due to changes in the building system or envelope. *The Building America program is used here to illustrate the fairly involved calculation methodology that is employed in the Building Systems Design Program.*

In the calculations, a set of baseline input estimates are used for all programs. The inputs have been divided into five categories: building stock, end-use loads, equipment market shares, equipment efficiencies, and replacement factors.

Building Stock

Building stock estimates are used to estimate the total energy savings at the national level for each program. The stock estimates have been developed for each market segment (building type, building vintage, and region) based on the following assumptions:

- 60% of the existing building stock is in the north.
- 40% of the existing building stock is in the south.
- New stock is divided evenly across regions.
- 0.6% annual degradation rate for existing residential buildings.
- 0.5% annual degradation rate for existing commercial buildings.

Residential and Commercial existing building stock totals for the years 1990, 2000, 2005, and 2010 were provided by EIA's *Annual Energy Outlook 1995* (AEO1995). Total stock for the years 2015 and 2020 are extrapolated from the 2010 stock number using the growth rate for the years 2005-2010. The model assumes that the existing stock degrades at a constant rate of 0.6% per year for residential buildings and 0.5% for commercial buildings. New stock is then calculated as the difference between the total stock as reported in AEO and the existing stock. Through the use of the assumptions listed above, the building stocks are segmented by building vintage and region. The base year is 1995, and all construction after 1995 is considered "new."

Disaggregation of the building stock into "north" and "south" regions was accomplished by using the EIA climate zones published in EIA's buildings consumption surveys, CBECS and RECS. Climate zones 1-3 (those zones with more than 4,000 heating-degree days) were designated as the "north" region, and zones 4 and 5 (those zones with less than 4,000 heating-degree days) were defined as the "south" region. Using this method, approximately 60% of the buildings are located in the north and 40% in the south. The split is assumed to remain constant throughout the analysis period, as the degradation rates are assumed to be equal across regions. It was assumed that new buildings would be split equally between the regions (50% north and 50% south) based on the pattern observed in the 1980s.

End-Use Loads

End-use load estimates are used to determine the existing load per unit (households for residential, square foot for commercial) for heating, cooling, and water heating so that energy savings due to the program being analyzed can be determined. The end-use loads are developed from loads generated by the DOE-2 simulation model and have been developed for each market segment (building type, building vintage, and region). To separate the loads into "north" and "south," a weighted average was developed by using CBECS climate zones 1-3 for the north and 4-5 for the south.

Residential Loads. Residential heating, and cooling loads were taken from an LBL study conducted in 1992 (Hanford and Huang 1992). In the analysis, building characteristics that were located in a Gas Research Institute (GRI) database were combined with component load values created by running DOE-2 simulations. Heating and cooling load results from DOE-2 were reduced to a set of regression coefficients that describe the contribution of each building component to overall building heating and cooling load. Building loads were then scaled by the building populations represented by each of building prototype populations. Four average buildings were defined: north/existing, north/new, south/existing, and south/new. Component loads were calibrated to the simulated building loads from the GRI database. National aggregate heating and cooling loads as reported in the GRI database were apportioned across buildings types by dividing the calculated load in each category by the population of buildings in the category.

Commercial Loads. Commercial heating and cooling load estimates are based on simulations of retail and office buildings using DOE-2.1d. To represent new buildings, the simulation models were set to minimal compliance levels for the ASHRAE Standard 90.1-1989. For existing buildings, a second set of simulation models were constructed that complied with the envelope requirements of ASHRAE Standard 90-75/90A-1980. The simulations were performed on three, three-story building types: retail, office, and other ("other" is a composite of 50% office and 50% retail).

Existing Buildings. Data from AEO 1992 was used to derive total heating and cooling consumption per square foot (kBtu/SF). Heating is the sum of gas, oil, electricity, and other. The national average heating and cooling loads that were derived from the DOE-2 simulations are used to create an adjustment factor that is designed to align the model with AEO estimates (AEO estimates were divided by DOE-2 estimate). Lastly, the DOE-2 north and south load estimates are adjusted by multiplying them by the adjustment factors.

New Buildings. It was assumed that new buildings are, on average, 20% more efficient for heating, and 10% more efficient for cooling than existing buildings.

Existing Equipment Market Shares

Equipment market shares are broken out by market segment and are estimated from CBECS, RECS, and original efforts by Pacific Northwest National Laboratory.

Equipment Efficiencies

The efficiency of equipment stock is developed from Annual Energy Outlook, 1994 (AEO, 1994) and input from program managers. Where applicable, the assumed stock efficiency increased to meet equipment standards.

Replacement Factors

Equipment replacement factors are used in the calculation of the number of units representing the potential target market for programs targeting specific pieces of equipment. It is assumed that BTS technologies compete only with "new" units. For new buildings, all units are considered new; thus, the replacement factor for equipment in new buildings is 1.0. For existing buildings, only those units that are scheduled for replacement are considered eligible for the BTS technology. In other words, it is assumed that the BTS technology does not replace a piece of equipment unless the equipment was going to be replaced anyway. The replacement factor for existing buildings for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1998 to 2000; the factor for 2005 represents the turnover percentage from 2001 to 2005, etc.). The replacement factors are based on the specific equipment's life expectancy.

Calculation Methodology

The steps involved in calculating the energy savings associated with Building America are:

- Determine size of potential market;
- Determine number of units affected by BTS program;
- Determine base space conditioning end-use loads;
- Determine space conditioning end-use loads after program implementation;
- Calculate energy savings;
- Calculate energy cost savings; and
- Calculate carbon reductions;

These steps are discussed below.

Determine Size of Potential Market

Building America targets new residential construction. The size of this potential market is shown in Table 220.1 and is part of the baseline assumptions. Table 220.1 shows the new residential building stock, in millions of households (HH), for the north and south regions. The stock of new buildings is defined as those built within the period (e.g., 2.40 million households are expected to be built in the north between 1998 and 2000); not the total new building stock (all buildings built since 1995). The last row of Table 220.1 represents the cumulative new building stock total (all buildings built since 1995).

Determine Number of Units Affected by BTS Program

The number of units affected by the BTS program is calculated using the program penetration rates **(Table 220.2)** and the building stock (Table 220.1). The penetration rates are applied to the appropriate market segment to compute the number of installed units (see **Table 220.3**). For the new building stock, this figure represents the number of installed units within that period, and not the cumulative number. Because energy savings are accumulated over time–a unit installed in 2000 will continue to save energy throughout its life–the number of installed units must be summed to represent the total number of installed units in the given year (see **Table 220.4**). Thus, the total number of installed units listed for 2005 in Table 220.3 (0.50) represents the number installed between 2000 and 2005, while the corresponding number in Table 220.4 (0.55) represents the number of units installed since the program was implemented.

Some envelope programs affect the existing building, stock, unlike Building America. The existing building stock is defined as the total stock built prior to 1995 in existence each year. The penetration into that building stock therefore represents the cumulative number of units to that time period, negating the need to accumulate the number of installed units.

Determine Base Space Conditioning End-Use loads

The end-use loads for new residential building heating and cooling are presented in Table 220.5, and are part of the baseline assumptions. The performance improvements for envelope programs are characterized by reductions in the space conditioning loads. It is therefore not necessary to explicitly calculate base energy consumption. Instead, the load reduction is applied to the base load to determine the new load, and the resulting difference in loads is used to calculate energy savings.

Determine Space Conditioning End-Use Loads After Program Implementation

The performance inputs for envelope programs are defined in terms of percent load reductions. The percent load reductions for Building America are presented in Table 220.6.

The load reductions are applied to the corresponding end-use load segment to determine the building level load reductions by end-use, presented in Table 220.7. The building level load reductions are translated into regional load reductions by multiplying the building level load reductions by the cumulative installed units for that region (given in Table 220.4). The regional load reductions are presented by end-use in Table 220.8.

Calculate Energy Savings

The regional load reductions must be translated into regional energy savings. To do this, baseline assumptions regarding existing equipment efficiencies and existing equipment market shares are used. First, the regional load reductions are divided by the baseline existing equipment efficiencies (listed in Table 220.9). This yields potential energy savings by equipment type and end-use, shown in Table 220.10. The potential energy savings assume that each equipment type has 100% of the market share, so the actual equipment market shares must then be applied. The baseline existing equipment market shares are presented in Table 220.11. The market share for each equipment type is multiplied by the potential energy savings calculated in Table 220.10 to determine the actual energy savings, presented in Table 220.12.

The savings calculated in Table 220.12 are aggregated by fuel type to determine the total delivered electric savings, total primary electric savings (equal to total delivered electric multiplied by an electricity conversion ratio of 3.019), total natural gas savings, total oil savings, and total primary savings. The energy savings are presented in Table 220.13.

Because the energy savings calculations are based on performance and penetration inputs specific to the program's FY 1996 budget request, they must be adjusted to account for changes between the FY 1996 budget request and the FY 1997 budget request. Table

220.14 presents the budget requests for FY 1996 and FY 1997. The ratio of FY97 to FY96 is multiplied by the total primary energy savings to yield the total primary budget adjusted savings presented in Table 220.15.

Calculate Energy Cost Savings

The energy cost savings are calculated using the energy savings by fuel (Table 220.15) and fuel prices (Table 220.16). The fuel prices are applied to the corresponding energy savings by fuel (the electricity price is multiplied by the estimate of delivered electricity) to yield the consumer cost savings presented in Table 220.17.

Calculate Carbon Equivalent Emissions Reductions

The carbon reductions are calculated using the energy savings by fuel (Table 220.15) and the carbon coefficients (Table 220.18). The carbon coefficients are applied to the corresponding energy savings by fuel (the electricity coefficient is applied to the primary electricity estimate) to yield the carbon reductions presented in Table 220.19.

[Note: Tables 220.1-10 referred in the answer to Q220a are attached following the answer to Q220b. DOE did not provide Tables 220.11-19.]

Q220b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A220b. The Department does not claim that the predicted benefits would not occur at all in the absence of DOE funding. It does believe, however, that the time frame wherein the energy benefits associated with improved residential and commercial building design begin to accrue will be accelerated significantly as a result of the proposed DOE funding. And since buildings have useful lives of anywhere from 30 to 100 years, the ability to accelerate building performance innovation by even as little as one year can result in significant accumulated savings over a lifetime of building occupancy.

The Department is playing an important role with the proposed funding, acting as a catalyst in the formation of several partnerships that are demonstrating the potential of energy efficiency in both new residential design and construction, and the retrofit of existing commercial buildings. It is also cost-sharing the development of advanced building design tools with Industry. Partnering efforts are deemed to be especially important in that the many different players in the design, construction and retrofit industries would not normally work in the cooperative fashion that is necessary to break down the traditional barriers to improved building energy performance. DOE has achieved several successes so far within this program, serving as an unbiased source of both management and technical expertise in getting the various parties to work together toward common goals. The program has also cost-shared the construction of several residential and small commercial buildings that serve as showcases for passive solar and energy efficient design concepts that can be replicated throughout the U.S.

APPENDIX TABLES FOR QUESTION 220.a

Table 220.1 **Building Stock** **Units:** Million households

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.75	1.60	2.40	4.20	4.40	4.75	4.75
Residential	New	South	0.75	1.60	2.40	4.20	4.40	4.75	4.75
Residential	New	All	1.50	3.20	4.80	8.40	8.80	9.50	9.50
Residential	New	Cumulative	1.50	4.70	9.50	17.90	26.70	36.20	45.70

Table 220.2 **Penetration Rates** **Units:** % of New Construction in Period

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00%	0.00%	1.00%	6.00%	15.00%	20.00%	25.00%
Residential	New	South	0.00%	0.00%	1.00%	6.00%	17.50%	25.00%	32.50%

Table 220.3 **Installed Units (New in Period)** **Units:** Million households

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.02	0.25	0.66	0.95	1.19
Residential	New	South	0.00	0.00	0.02	0.25	0.77	1.19	1.54
Residential	New	Total	0.00	0.00	0.05	0.50	1.43	2.14	2.73

Table 220.4 **Cumulative Installed Units** **Units:** Million households

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.02	0.28	0.94	1.89	3.07
Residential	New	South	0.00	0.00	0.02	0.28	1.05	2.23	3.78
Residential	New	Total	0.00	0.00	0.05	0.55	1.98	4.12	6.85

Table 220.5 **End-Use Loads** **Units:** MBtu/HH/Year

Table 220.5a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	43.10	43.10	43.10	43.10	43.10	43.10	43.10
Residential	New	South	12.60	12.60	12.60	12.60	12.60	12.60	12.60

Table 220.5b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	8.80	8.80	8 80	8.80	8.80	8.80	8.80
Residential	New	South	16.90	16.90	16.90	16.90	16.90	16.90	16.90

Table 220.6 **Performance Inputs** **Units:** % load reduction

Table 220.6a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00%	0.00%	10.50%	21.00%	21.00%	21.00%	21.00%
Residential	New	South	0.00%	0.00%	14.50%	29.00%	29.00%	29.00%	29.00%

Table 220.6b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00%	0.00%	9.00%	18.00%	18.00%	18.00%	18.00%
Residential	New	South	0.00%	0.00%	7.00%	14.00%	14.00%	14.00%	14.00%

Table 220.7 **Building Level Load Reductions** **Units:** MBtu/HH/Year

Table 220.7a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	4.53	9.05	9.05	9.05	9.05
Residential	New	South	0.00	0.00	1.83	3.65	3.65	3.65	3.65

Table 220.7b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.79	1.58	1.58	1.58	1.58
Residential	New	South	0.00	0.00	1.18	2.37	2.37	2.37	2.37

Table 220.8 **Regional Load Reductions** **Units:** TBtu/Year

Table 220.8a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	2	8	17	28
Residential	New	South	0	0	0	1	4	8	14

Table 220.8b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	3	5
Residential	New	South	0	0	0	1	2	5	9

Table 220.9 **Existing Equipment Efficiencies**

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Space Heating	Electricity	Forced Air	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Space Heating	Gas	Furnace	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Space Heating	Oil	Furnace	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Space Cooling	Electricity	Heat Pump	2.93	2.93	2.93	2.93	2.93	2.93	2.93
Space Cooling	Electricity	Central Air	2.93	2.93	2.93	2.93	2.93	2.93	2.93

Table 220.10 **Potential Energy Savings** **Units:** Tbtu/Year

Table 220.10a **Equipment:** Electric Heat Pump

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	4	9	14
Residential	New	South	0	0	0	1	2	4	7

Table 220.10b **Equipment:** Electric Forced Air

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	2	8	17	28
Residential	New	South	0	0	0	1	4	8	14

Table 220.10c **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	3	11	22	36

Table 220.10d **Equipment:** Oil Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	3	11	22	36
Residential	New	South	0	0	0	1	5	10	18

Table 220.10e **Equipment:** Electric Heat Pump

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	1	2
Residential	New	South	0	0	0	0	1	2	3

Table 220.10f **Equipment:** Electric Central Air

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	1	2
Residential	New	South	0	0	0	0	1	2	3

Table 220.11 **Existing Equipment Market Shares** **Units:** % of Households

Table 220.11a **Region:** North

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	21.8%	21.8%	21.7%	21.6%	19.0%	18.7%	18.3%
Space Heating	Electricity	Forced Air	19.7%	20.1%	20.4%	20.9%	21.6%	21.6%	21.6%
Space Heating	Gas	Furnace	32.7%	31.4%	30.1%	27.3%	23.6%	23.5%	23.4%
Space Heating	Oil	Furnace	11.0%	11.0%	10.9%	10.8%	10.7%	10.7%	10.7%
Space Cooling	Electricity	Heat Pump	20.3%	20.3%	20.2%	20.2%	18.0%	18.0%	18.0%
Space Cooling	Electricity	Central Air	59.2%	58.2%	57.1%	55.2%	52.5%	52.5%	52.4%

Table 220.11b **Region:** South

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	21.8%	21.8%	21.7%	21.6%	19.0%	18.7%	18.3%
Space Heating	Electricity	Forced Air	19.7%	20.1%	20.4%	20.9%	21.6%	21.6%	21.6%
Space Heating	Gas	Furnace	32.7%	31.4%	30.1%	27.3%	23.6%	23.5%	23.4%
Space Heating	Oil	Furnace	11.0%	11.0%	10.9%	10.8%	10.7%	10.7%	10.7%
Space Cooling	Electricity	Heat Pump	20.3%	20.3%	20.2%	20.2%	18.0%	18.0%	18.0%
Space Cooling	Electricity	Central Air	59.2%	58.2%	57.1%	55.2%	52.5%	52.5%	52.4%

Table 220.12 **Actual Energy Savings** **Units:** Tbtu/Year

Table 220.12a **Equipment:** Electric Heat Pump

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	2	3
Residential	New	South	0	0	0	0	0	1	1

Table 220.12b **Equipment:** Electric Forced Air

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	2	4	6
Residential	New	South	0	0	0	0	1	2	3

Table 220.12c **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	3	5	8
Residential	New	South	0	0	0	0	1	2	4

Table 220.12d **Equipment:** Oil Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	2	4
Residential	New	South	0	0	0	0	1	1	2

Table 220.12e **Equipment:** Electric Heat Pump

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	0	0	0
Residential	New	South	0	0	0	0	0	0	1

Table 220.12f **Equipment:** Electric Central Air

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	0	1	1
Residential	New	South	0	0	0	0	0	1	2

Table 220.13 **Energy Savings, All Equipment Types and End-Uses** Units: Tbtu/Year

Table 220.13a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	3	6	10
Residential	New	South	0	0	0	0	2	4	6
Total			0	0	0	1	5	10	16

Table 220.13b Primary Electricity **Electricity Conversion Ratio:** 3.019

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	3	9	18	29
Residential	New	South	0	0	0	1	5	11	19
Total			0	0	0	4	14	30	49

Table 220.13c Natural Gas

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	3	5	8
Residential	New	South	0	0	0	0	1	2	4
Total			0	0	0	1	4	8	12

Table 220.13d Oil

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	2	4
Residential	New	South	0	0	0	0	1	1	2

Total			0	0	0	0	2	3	6

Table 220.13e Total Primary

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	4	13	26	42
Residential	New	South	0	0	0	2	7	15	25
Total			0	0	0	6	20	41	67

Table 220.14 Budget Adjustment

FY 96 Budget Request:	5.874	million $
FY 97 Budget Request:	7.062	million $

Table 220.15 Budget Adjusted Energy Savings, All Equipment Types and End-Uses Units:
Tbtu/Year

Table 220.15a Delivered Electricity

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	4	7	12
Residential	New	South	0	0	0	1	2	5	8
Total			0	0	0	2	6	12	19

Table 220.15b Primary Electricity **Electricity Conversion Ratio:** 3.019

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	3	11	22	35
Residential	New	South	0	0	0	2	6	14	23
Total			0	0	0	5	17	36	59

Table 220.15c Natural Gas

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	3	6	10
Residential	New	South	0	0	0	0	1	3	5
Total			0	0	0	1	4	9	15

Table 220.15d Oil

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	3	5
Residential	New	South	0	0	0	0	1	1	2
Total			0	0	0	1	2	4	7

Table 220.15e Total Primary

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020

Residential	New	North	0	0	0	5	15	31	50
Residential	New	South	0	0	0	2	9	18	30
Total			0	0	0	7	24	49	80

Table 220.16 **Fuel Prices** **Units:** 1995 $ / MBtu

Building Type	Fuel Type	1995	1997	2000	2005	2010	2015	2020
Residential	Electricity	24.82	24.95	25.15	26.36	27.64	28.15	28.66
Residential	Natural Gas	6.46	6.45	6.44	7.16	7.48	8.16	8.89
Residential	Oil	7.07	7.46	8.06	8.55	9.05	9.57	10.13

Table 220.17 **Consumer Cost Savings** **Units:** Million 1995 $

Table 220.17a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	1	29	100	203	335
Residential	New	South	0	0	1	15	59	129	220
Total			0	0	2	44	159	332	556

Table 220.17b **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	8	23	50	89
Residential	New	South	0	0	0	3	10	24	44

Total			0	0	0	11	33	75	133

Table 220.17c Oil

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	4	13	27	46
Residential	New	South	0	0	0	1	6	13	23
Total			0	0	0	5	18	40	70

Table 220.17d Total

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	2	40	135	281	471
Residential	New	South	0	0	1	20	75	166	288
Total			0	0	2	60	211	446	759

Table 220.18 Carbon Coefficients Units: MM Tons / QBtu

Fuel Type	Coefficient
Electricity	22.32
Natural Gas	14.69
Oil	19.65

Table 220.19 **Carbon Equivalent Emissions Reductions** **Units:** MM Ton / Year

Table 220.19a **Primary Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.07	0.24	0.49	0.79
Residential	New	South	0.00	0.00	0.00	0.04	0.14	0.31	0.52
Total			0.00	0.00	0.00	0.11	0.39	0.79	1.31

Table 220.19b **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.02	0.05	0.09	0.15
Residential	New	South	0.00	0.00	0.00	0.01	0.02	0.04	0.07
Total			0.00	0.00	0.00	0.02	0.07	0.13	0.22

Table 220.19c **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.01	0.03	0.06	0.09
Residential	New	South	0.00	0.00	0.00	0.00	0.01	0.03	0.04
Total			0.00	0.00	0.00	0.01	0.04	0.08	0.13

Table 220.19d **Total**

Building Type	Building Vintage			Building Region			1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.10	0.32	0.63	1.03				
Residential	New	South	0.00	0.00	0.00	0.05	0.18	0.38	0.64				
Total		0.00	0.00	0.01	0.15	0.49	1.01	1.66					

Q221. Please provide a listing of the recipients of (i) the $7,194,000 in funding in FY 1995, (ii) the $6,674,000 in FY 1996 funding, and (iii) the requested level of $11,662,000 in FY 1997 for Residential Buildings.

A221. The recipients are listed in the table immediately below in answer to the next question.

Q222. For each recipient of Residential Buildings funds identified in the response to question 221 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A222. The listing of recipient cost-sharing is listed below.

Residential Buildings Planning Unit
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	IBACOS Consortium	2,500	2,900	TBD	N
2	Building Science Consortium (BSC)	800	3,100	TBD	Y
3	Consortium for Advanced Residential Buildings (CARB)	2,300	2,800	TBD	Y
4	Hickory Consortium	200	300	TBD	Y
5	University of Oregon	78	75	TBD	N
6	Florida Solar Energy	427	467	TBD	N
7	Penn State University	15	15	TBD	Y
8	Auburn University	60	70	TBD	N
9	Structural Insulated Panel Association (SIPA)	10	10	TBD	N
10	Princeton Synergetics	5	5	TBD	N
11	Building Systems Council of the National Association of Home Builders	0	0	TBD	N
12	Habitat for Humanity	0	0	TBD	N
13	NAHB Research Center	1,230	542	TBD	N
14	LBNL*			TBD	N
15	NREL*			TBD	N
16	ORNL*			TBD	N
17	PNNL*			TBD	N
	Total	**7,625**	**10,284**	**TBD**	

*Cost-Share for National Laboratories includes funding from other sources such as other agencies, user fees, etc

Q223. For those Residential Buildings funding recipients identified in the response to question 221 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A223. Justification for non-competitive awards in Residential Building Planning unit as identified in the table above are as follows:

1. The IBACOS consortium was selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

5. The University of Oregon and its research partner, the Florida Solar Energy Center (6) were selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

8. Auburn University was selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

9. The Structural Insulated Panel Association was selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

10. Princeton Synergetics was selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

11. The Building Systems Council of the National Association of Home Builders is funded through DOE support to the University of Oregon and the Florida Solar Energy Center. It was selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

12. Energy evaluation for houses to be constructed by Habitat for Humanity Affiliates is provided through DOE support to the Florida Solar Energy Center. This project was selected on an unsolicited proposal basis and a sole source justification was based on unique capabilities.

13. NAHB Research Center was selected on an unsolicited proposal basis and sole source justification was based on unique capability.

14-17. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory.

Q224. Please identify each of the four consortia in the Building America program, including the membership of each, and both DOE and private-sector funding to each for the period FY 1994 - FY 1997.

A224. Building America is the U.S. Department of Energy/industry-team partnership program that applies systems engineering research approaches to accelerate the development and adoption of building process and technical systems innovations for energy efficient, environmentally sensitive, affordable and adaptable residences on a community scale. Field support is provided by the National Renewable Energy Laboratory (NREL).

The systems innovations developed by Building America industry teams are intended to reduce energy use, construction time, and construction waste by 50 percent, relative to a 1990 base case. The program participants include residential builders, designers, material suppliers, equipment manufacturers, financial institutions, and related organizations.

These industry groups have traditionally worked independently of one another, slowing development and adoption of new technologies. By working together using a systems engineering research approach, decisions previously made independently can quickly be made with consideration for the entire design, manufacturing, and construction process, thereby reducing barriers and increasing quality and performance without increasing cost.

The four Building America consortia collectively have committed over $30 million in direct cost-shared participation over the next four years for full-scale system engineering of housing technology innovations. In addition to systems engineering analysis, the industry partners are constructing prototype homes, and the participating builder team members are evaluating the potential for large-scale replication.

DOE is providing cost-shared support for research and development. Construction costs are funded by the industry teams. DOE funds are leveraged 2:1 over the life of the program.

Building America Industry Teams

IBACOS

IBACOS (Integrated Building and Construction Solutions) of Pittsburgh, Pennsylvania is the first DOE-supported consortium in the Building America program that began in 1994. IBACOS' mission is to bring about the production of EQA homes. EQA homes will be energy Efficient and Environmentally responsive; Quick to build and top Quality; and Affordable and Adaptable. The IBACOS approach is to serve as catalyst for the development and commercialization of innovative new housing products and systems. The IBACOS Consortium has completed a base house and a lab house in Pittsburgh as well as a test house in Austin, Texas. Technical advances demonstrated in the Pittsburgh lab house have resulted in a 42% reduction in annual energy use compared to the base house, built to the local energy code. The individual team member organizations are:

1. **IBACOS**, 2214 Liberty Avenue, Pittsburgh, PA 15222-4502.
2. **Burt Hill Kosar Rittelmann Associates**, 400 Morgan Center, Butler, PA 16001.
3. **GE Plastics**, One Plastics Avenue, Pittsfield, MA 10201.
4. **Masco Corporation**, 21001 Van Born Road, Taylor, MI 48180.
5. **Delta Faucet Company**, 55 E. 11th Street, Indianapolis, IN 46280.
6. **KraftMaid Cabinetry**, 16052 Industrial Parkway, Middlefield, OH 44062.
7. **Trayco**, 693 South Court, Lapeer, MI 48446.
8. **USG Corporation Research Center**, 700 North Highway 45, Libertyville, IL 60048.
9. **Carrier Corporation**, 7310 W. Morris Street, Indianapolis, IN 46231.
10. **GE Appliances**, Appliance Park AP4-291, Louisville, KY 40226.
11. **Molex**, 2222 Wellington Court, Lisle, IL 60532-1682.
12. **EPAC Development**, 3070 Bristol Street, Suite 520, Costa Mesa, CA 92626.
13. **Pulte Home Corporation**, 33 Bloomfield Hills Parkway, Suite 200, Bloomfield Hills, MI 48304-4601.
14. **Pulte Home Corporation**, Chesapeake Division, 11120 New Hampshire Ave., Suite 208, Silver Spring, MD 20904.
15. **RGC**, 20 Corporate Plaza, Newport Beach, CA 92660.
16. **Sundance Homes**, 1375 E. Woodfield Road, Suite 600, Schaumburg, IL 60173.
17. **Doyle Wilson Homebuilder, Inc.**, 6805 Capitol of Texas Hwy, Suite 300, Austin, TX 78731.

BUILDING SCIENCE CONSORTIUM (BSC)

In alphabetical order, the first of the three new consortia, chosen through the competitive Request for Proposal process in 1995, is the Building Science Consortium, (BSC). It is headed by the Building Science Corporation of Chestnut Hill, Massachusetts, an innovative housing design and engineering firm which is recognized internationally for expertise in moisture control and indoor air quality. The BSC industry team members are working together in developing systems improvements by analyzing the existing components and applications in residential construction and reallocating resources for more cost effective systems performance. BSC has completed three test houses at Prairie Crossing, near Chicago, which will use approximately 50 percent less energy for heating, cooling, and hot water than houses in neighboring suburbs along with a decrease in construction cost. A fourth test house has recently been completed near Charlotte, North Carolina. Individual team members are:

1. **Building Science Corporation**, 273 Russett Road, Chestnut Hill, MA 02167.
2. **DEC International**, Therma-Stor Products, 1919 S. Stoughton, P.O. Box 8050, Madison, WI 53708.
3. **Energy Efficient Building Association**, 2950 Metro Drive, Suite 108, Minneapolis, MN 55425.
4. **Florida Solar Energy Center**, 1679 Clear Lake Road, Cocoa, FL 32922-5703.
5. **Pulte Home Corporation**, Las Vegas Division, 7330 Smoke Ranch, Suite B, Las Vegas, NV 89128.
6. **Pulte Home Corporation**, South Florida Division, 1350 E. Newport, Suite 200, Deerfield Beach, FL 33442.
7. **Pulte Home Corporation**, Charlotte Division, 6801 Fairview Road, Charlotte, NC 28210.
8. **Pulte Home Corporation**, Central Florida Division, 555 Winderley Place, Suite 420, Maitland, FL 32751.
9. **Shaw Homes**, 501 West Peterson Road, Libertyville, IL 60048.
10. **Tascon**, 7607 Fairview, Houston, TX 77041.
11. **University of Minnesota**, Department of Forest Products, 1365 Ryan Avenue, Roseville, MN 55113.
12. **RCD Corporation**, P.O. Box 1020, Eustis, FL 32727-1020.
13. **Coleen Donohue**, C.P.A., 108 Union Wharf, Boston, MA 02109.

CONSORTIUM FOR ADVANCED RESIDENTIAL BUILDINGS (CARB)

Steven Winter Associates, an architecture, engineering, energy and building systems consulting firm in Norwalk, Connecticut, leads the second of the new consortia, CARB, (Consortium for Advanced Residential Buildings). The goals of CARB are to increase productivity and profits of the American residential building industry by constructing houses that are higher quality, more affordable, and energy and resource efficient. Over the next three years, CARB will build a series of prototype townhouses and full-scale developments that will test these goals in the marketplace. The first two townhouses will be completed during the third quarter of 1996. The CARB team members are:

1. **Steven Winter Associates**, 50 Washington Street, Norwalk, CT 06854.
2. **Andersen Corporation**, 100 Fourth Avenue, Bayport, MN 55003-1096.

3. **Inter-City Products Corporation**, 1136 Heil Quaker Boulevard, Lavergne, TN 37086-1985.
4. **Ryan Homes**, NVR Building Products Company, Quince Diamond, Gaithersburg, MD 20878.
5. **U.S. Steel**, 600 Grant Street, Pittsburgh, PA 15219-2749.
6. **Westinghouse Electric Supply Company**, 3719 Corporex Park, Tampa, FL 33619.
7. **Weyerhaeuser Corporation**, Mail Stop TWC 2B2, Tacoma, WA 98477.
8. **Whirlpool Corporation**, 2000 M-63, MD, 4303 Benton Harbor, MI 49022.
9. **Owens-Corning**, Fiberglas Tower, Toledo, OH 43659.
10. **Del Webb Corporation**, 6001 N. 24th Street, Phoenix, AZ 85016.
11. **Norwest Mortgage**, c/o Lane IL Group, 1440 S. Emerson, Denver, CO 80210.
12. **State Farm Insurance**, 112 East Washington Street, Bloomington, IL 61701.

HICKORY CONSORTIUM

Hickory Consortium, the third new consortium, is headed by Building Science Engineering of Harvard, Massachusetts, a consulting firm for whole-building integrated design focusing on energy efficiency, air quality, and environmental values. The industry members of this consortium are developing a systems dynamics model of processes that the housing industry uses to produce and deliver housing, from raw materials through occupancy. Using the results of this model, a modular house with superior energy efficiency and environmental design is planned to be designed and constructed during the first half of 1996. Team members are:

1. **Hickory Corporation**, 11 Paterson's Brook Road, P.O. Box 299, West Wareham, MA 02576.
2. **Acorn Laboratories**, Keefe Road, Acton, MA 01720.
3. **Building Science Engineering**, 85 Depot Road, Harvard, MA 01451.
4. **Center for Maximum Potential Building Systems**, 8694 FM 969, Austin, TX 78724.
5. **ASNI Associates**, 3 Rolf Road, Lexington, MA 02173-2307.
6. **Hampton Architect**, Stow Road, Harvard, MA 01451.
7. **Pella Corporation**, 102 Main Street, Pella, IA 50219.
8. **Maida Enterprises**, 102 Ripley Street, Newton Centre, MA 02159.
9. **Tamarack Technologies**, P.O. Box 490, West Wareham, MA. 02576.
10. **Ventana Systems**, 60 Jacob Gates Road, Harvard, MA 01451.
11. **Benson Woodworking**, R.R. 1, Box 224, Alstead, NH 03602.
12. **Deck House/Acorn Structures**, 930 Main Street, Acton, MA 01720.
13. **Epoch Corporation**, P.O. Box 235, Route 106, Pembroke, NH 03275.
14. **Finetine Woodworking**, 459 Liberty Square Road, Foxboro, MA 01719.
15. **Oaktree Development**, 950 Massachusetts Avenue, Cambridge, MA 02139.
16. **Transnational Corporation**, 221 Egypt Road, Raymond, ME 04071.

(In Thousands of $)

No.	Major Recipient	Cost-Share				Competitive
		FY 1994	FY 1995	FY 1996	FY 1997	
1	IBACOS Consortium	1,900	2,500	2,900	TBD	N
2	Building Science Consortium (BSC)	0*	800	3,100	TBD	Y
3	Consortium for Advanced Residential Buildings (CARB)	0*	2,300	2,800	TBD	Y
4	Hickory Consortium	0*	200	300	TBD	Y
	Total	**1,900**	**5,800**	**9,100**	**TBD**	

*Evaluation had not been completed of the submissions to the competitive Request for Proposals for additional Building America teams.

(In Thousands of $)

No.	Major Recipient	DOE Funding				Competitive
		FY 1994	FY 1995	FY 1996	FY 1997	
1	IBACOS Consortium	1,200	1,700	1,050	TBD	N
2	Building Science Consortium (BSC)	0*	487	460	TBD	Y
3	Consortium for Advanced Residential Buildings (CARB)	0*	683	819	TBD	Y
4	Hickory Consortium	0*	239	240	TBD	Y
	Total	**1,200**	**3,109**	**2,569**	**TBD**	

*Evaluation had not been completed of the submissions to the competitive Request for Proposals for additional Building America teams.

Q225. Please describe the Integrated Building and Construction Solutions (IBACOS), and provide details of both DOE and private-sector funding for the period FY 1994 - FY 1997.

A225. A description of the Integrated Building and Construction Solutions (IBACOS), its members and funding details are provided above in answer 224 (A224). *[Reproduced here.]*

IBACOS (Integrated Building and Construction Solutions) of Pittsburgh, Pennsylvania is the first DOE-supported consortium in the Building America program that began in 1994. IBACOS' mission is to bring about the production of EQA homes. EQA homes will be energy Efficient and Environmentally responsive; Quick to build and top Quality; and Affordable and Adaptable. The IBACOS approach is to serve as catalyst for the development and commercialization of innovative new housing products and systems. The IBACOS Consortium has completed a base house and a lab house in Pittsburgh as well as a test house in Austin, Texas. Technical advances demonstrated in the Pittsburgh lab house have resulted in a 42% reduction in annual energy use compared to the base house, built to the local energy code. The individual team member organizations are:

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3. **GE Plastics**, One Plastics Avenue, Pittsfield, MA 10201.
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5. **Delta Faucet Company**, 55 E. 11th Street, Indianapolis, IN 46280.
6. **KraftMaid Cabinetry**, 16052 Industrial Parkway, Middlefield, OH 44062.

7. **Trayco**, 693 South Court, Lapeer, MI 48446.
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17. **Doyle Wilson Homebuilder, Inc.**, 6805 Capitol of Texas Hwy, Suite 300, Austin, TX 78731.

Integrated Building and Construction Solutions (IBACOS) Funding
(In Thousands of $)

Funding	**FY 1994**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
DOE	1,200	1,700	1,050	TBD	N
Cost-Share	1,900	2,500	2,900	TBD	N
Total	**3,100**	**4,200**	**3,950**	**TBD**	

Q226. Please describe the Building Science Consortium, including details of its membership and both DOE and private-sector funding for the period FY 1994 - FY 1997.

A226. A description of the Building Science Consortium, its members and detailed funding are provided above in answer 224 (A224). *[Reproduced here.]*

In alphabetical order, the first of the three new consortia, chosen through the competitive Request for Proposal process in 1995, is the Building Science Consortium, (BSC). It is headed by the Building Science Corporation of Chestnut Hill, Massachusetts, an innovative housing design and engineering firm which is recognized internationally for expertise in moisture control and indoor air quality. The BSC industry team members are working together in developing systems improvements by analyzing the existing components and applications in residential construction and reallocating resources for more cost effective systems performance. BSC has completed three test houses at Prairie Crossing, near Chicago, which will use approximately 50 percent less energy for heating, cooling, and hot water than houses in neighboring suburbs along with a decrease in construction cost. A fourth test house has recently been completed near Charlotte, North Carolina. Individual team members are:

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3. **Energy Efficient Building Association**, 2950 Metro Drive, Suite 108, Minneapolis, MN 55425.
4. **Florida Solar Energy Center**, 1679 Clear Lake Road, Cocoa, FL 32922-5703.

5. **Pulte Home Corporation**, Las Vegas Division, 7330 Smoke Ranch, Suite B, Las Vegas, NV 89128.
6. **Pulte Home Corporation**, South Florida Division, 1350 E. Newport, Suite 200, Deerfield Beach, FL 33442.
7. **Pulte Home Corporation**, Charlotte Division, 6801 Fairview Road, Charlotte, NC 28210.
8. **Pulte Home Corporation**, Central Florida Division, 555 Winderley Place, Suite 420, Maitland, FL 32751.
9. **Shaw Homes**, 501 West Peterson Road, Libertyville, IL 60048.
10. **Tascon**, 7607 Fairview, Houston, TX 77041.
11. **University of Minnesota**, Department of Forest Products, 1365 Ryan Avenue, Roseville, MN 55113.
12. **RCD Corporation**, P.O. Box 1020, Eustis, FL 32727-1020.
13. **Coleen Donohue**, C.P.A., 108 Union Wharf, Boston, MA 02109.

Building Science Consortium (BSC) Funding
(In Thousands of $)

Funding	FY 1994	FY 1995	FY 1996	FY 1997	Competitive
DOE	0*	487	460	TBD	Y
Cost-Share	0*	800	3,100	TBD	Y
Total	**0***	**1,287**	**3,500**	**TBD**	

*Evaluation had not been completed of the submissions to the competitive Request for Proposals for additional Building America teams.

Q227. Please describe the Consortium for Advanced Residential Buildings, including details of its membership and both DOE and private-sector funding for the period FY 1994 - FY 1997.

A227. A description of the Consortium for Advanced Residential Buildings, its members and funding details are provided above in answer 224 (A224). *[Reproduced here.]*

Steven Winter Associates, an architecture, engineering, energy and building systems consulting firm in Norwalk, Connecticut, leads the second of the new consortia, CARB, (Consortium for Advanced Residential Buildings). The goals of CARB are to increase productivity and profits of the American residential building industry by constructing houses that are higher quality, more affordable, and energy and resource efficient. Over the next three years, CARB will build a series of prototype townhouses and full-scale developments that will test these goals in the marketplace. The first two townhouses will be completed during the third quarter of 1996. The CARB team members are:

1. **Steven Winter Associates**, 50 Washington Street, Norwalk, CT 06854.
2. **Andersen Corporation**, 100 Fourth Avenue, Bayport, MN 55003-1096.
3. **Inter-City Products Corporation**, 1136 Heil Quaker Boulevard, Lavergne, TN 37086-1985.
4. **Ryan Homes**, NVR Building Products Company, Quince Diamond, Gaithersburg, MD 20878.
5. **U.S. Steel**, 600 Grant Street, Pittsburgh, PA 15219-2749.
6. **Westinghouse Electric Supply Company**, 3719 Corporex Park, Tampa, FL 33619.
7. **Weyerhaeuser Corporation**, Mail Stop TWC 2B2, Tacoma, WA 98477.
8. **Whirlpool Corporation**, 2000 M-63, MD, 4303 Benton Harbor, MI 49022.
9. **Owens-Corning**, Fiberglas Tower, Toledo, OH 43659.

10. **Del Webb Corporation**, 6001 N. 24th Street, Phoenix, AZ 85016.
11. **Norwest Mortgage**, c/o Lane IL Group, 1440 S. Emerson, Denver, CO 80210.
12. **State Farm Insurance**, 112 East Washington Street, Bloomington, IL 61701.

Consortium for Advanced Residential Buildings (CARB) Funding
(In Thousands of $)

Funding	FY 1994	FY 1995	FY 1996	FY 1997	Competitive
DOE	0*	683	819	TBD	Y
Cost-Share	0*	2,300	2,800	TBD	Y
Total	**0***	**2,983**	**3,619**	**TBD**	

*Evaluation had not been completed of the submissions to the competitive Request for Proposals for additional Building America teams.

Q228. Please describe the Hickory Consortium, including details of its membership and both DOE and private-sector funding for the period FY 1994 - FY 1997.

A228. A description of the Hickory Consortium, its members and funding details are provided above in answer 224 (A224). *[Reproduced here.]*

Hickory Consortium, the third new consortium, is headed by Building Science Engineering of Harvard, Massachusetts, a consulting firm for whole-building integrated design focusing on energy efficiency, air quality, and environmental values. The industry members of this consortium are developing a systems dynamics model of processes that the housing industry uses to produce and deliver housing, from raw materials through occupancy. Using the results of this model, a modular house with superior energy efficiency and environmental design is planned to be designed and constructed during the first half of 1996. Team members are:

1. **Hickory Corporation**, 11 Paterson's Brook Road, P.O. Box 299,
   West Wareham, MA 02576.
2. **Acorn Laboratories**, Keefe Road, Acton, MA 01720.
3. **Building Science Engineering**, 85 Depot Road, Harvard, MA 01451.
4. **Center for Maximum Potential Building Systems**, 8694 FM 969, Austin, TX 78724.
5. **ASNI Associates**, 3 Rolf Road, Lexington, MA 02173-2307.
6. **Hampton Architect**, Stow Road, Harvard, MA 01451.
7. **Pella Corporation**, 102 Main Street, Pella, IA 50219.
8. **Maida Enterprises**, 102 Ripley Street, Newton Centre, MA 02159.
9. **Tamarack Technologies**, P.O. Box 490, West Wareham, MA 02576.
10. **Ventana Systems**, 60 Jacob Gates Road, Harvard, MA 01451.
11. **Benson Woodworking**, R.R. 1, Box 224, Alstead, NH 03602.
12. **Deck House/Acorn Structures**, 930 Main Street, Acton, MA 01720.
13. **Epoch Corporation**, P.O. Box 235, Route 106, Pembroke, NH 03275.
14. **Finetine Woodworking**, 459 Liberty Square Road, Foxboro, MA 01719.
15. **Oaktree Development**, 950 Massachusetts Avenue, Cambridge, MA 02139.
16. **Transnational Corporation**, 221 Egypt Road, Raymond, ME 04071.

Hickory Consortium Funding
(In Thousands of $)

Funding	FY 1994	FY 1995	FY 1996	FY 1997	Competitive
DOE	0*	239	240	TBD	Y
Cost-Share	0*	200	300	TBD	Y
Total	**0***	**439**	**540**	**TBD**	

*Evaluation had not been completed of the submissions to the competitive Request for Proposals for additional Building America teams.

Q229. Please describe the Energy Efficient Industrialized Housing program, including details of participants and both DOE and private-sector funding for the period FY 1994 - FY 1997.

A229. The Energy Efficient Industrialized Housing Program (EEIH) of the U.S. Department of Energy (DOE) seeks to increase the energy performance, quality, comfort and affordability of new residential housing by influencing the market acceptance of innovative factory-oriented design and construction methods. The goal is to make possible the innovative industrialization of residential housing and large-scale site assembled components that are, on average, 50% more energy efficient and also less costly than those built today using conventional construction techniques.

To date, working with the private sector, the EEIH program has provided design and consulting services for the construction of three experimental energy efficient houses that demonstrate the effectiveness of industrialized building component and materials technologies. Energy performance improvements approaching the 50% long term goal have been achieved in these demonstrations. Significant builder and supplier involvement in these projects has stimulated their interest in adopting advanced manufacturing technology as a means of improving market share.

The first of these houses, designed by the University of Oregon Center for Housing Innovation, in Eugene, Oregon, is an experimental structural insulated panel house, Springfield 1, a 1200-square-foot, one and one half story, demonstration house, dedicated on July 9, 1994, was constructed in a cost-shared program for the St. Vincent de Paul Society, with materials and expertise donated by over 40 organizations. The house is designed to use 40% less energy than an Oregon code house and has a R49 roof; R26 walls; R30 floors; and double glazed, low-E, argon filled, energy efficient windows. Energy monitoring and evaluation of the performance of the house are being conducted by the Florida Solar Energy Center (FSEC).

At MetroWest, in Orlando, Florida, another joint FSEC and University of Oregon project, the "Spirit of Today" house, was developed in cooperation with *Better Homes and Gardens* magazine. It had its "open house" in January 1995 and is 3,500 square-feet in size because of *Better Homes and Gardens* request for a large energy efficient house to be featured in their magazine.

Construction was privately financed with considerable donations of materials and support on the part of manufacturers and the magazine. The October 1994 issue featured an 11-page article under the title of the "Forever Young House" and also included the design of an 1,800-square-foot "Modified Forever Young" house, employing the same energy saving and environmentally friendly characteristics. Building plans for both houses are available from the magazine. The house combines energy and water efficiency (50% better than codes) with handicapped accessibility, environmentally friendly materials, excellent indoor air quality and exciting design, all delivered though panelized construction.

The third project, the Orlando Health House '95, of the American Lung Association of Central Florida, opened for a week of public tours on December 8, 1995. This 3,750 square-foot house has been a collaborative program between the DOE EEIH program: FSEC; the American Lung Association of Central Florida: the builder, Scott L. Philpot; Tuscawilla Realty; and *Professional Builder* Magazine to showcase the latest construction techniques and products for creating a living environment that is healthy and energy efficient.

The use of a dehumidification system; high efficiency filters; and a tight duct system in this energy efficient house is intended to eliminate not only pollen and dust but also dust mites, which according to allergists are a leading cause of allergy related illness and asthma in Florida. With the approval of the family purchasing this house, testing will continue for 1-3 years by FSEC in cooperation with the College of Medicine at the University of Southern Florida.

Another energy efficient house being monitored by FSEC is a direct private sector spin-off from the Springfield I structural insulated panel house, with the addition of a full basement. It is called the Resource Efficient and Affordable Demonstration Home (READ) and is located in East Lansing, Michigan. The basement walls of this 1,200 square foot, story and one half, house are also of structural insulated panel construction. with a pressure treated plywood outer skin. Support for the construction of this house was obtained from the panel manufacturer, Great Lakes Insulspan; from John Banie Associates, architects; from Sunway Builders; and from the Consumers Power Company. Also, the EEIH program has an active consulting relationship for energy efficiency and affordability with major non-profit building organizations such as Habitat for Humanity and the St. Vincent de Paul Society. In addition to these houses, under the EEIH program, FSEC has monitored and inspected over 25 industrialized houses, in factories and on site, in a number of states. These tests have helped participating industries to adjust factory processes and materials selection to improve energy performance. Infrared inspection and other testing have also verified the performance of manufactured HUD-Code housing.

A prototype manufacturing facility simulation computer model has been developed at the Industrial Engineering Department of the University of Central Florida. It has been used by a major panelized housing manufacturer to forecast and verify increased output.

Created primarily for architects and large production builders, is an initial energy design software module developed for use with Autodesk, a popular architectural design software program that automates building material specification and selection. It was developed through a cooperative research and development agreement (CRADA) with Softdesk, the University of Oregon, and Pacific Northwest Laboratory.

(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1994**	**FY 1995**	**FY 1996**	**FY 1997**
1	University of Oregon	180	78	75	TBD
2	Florida Solar Energy Center (FSEC)	327	427	467	TBD
3	Pennsylvania State University	15	15	15	TBD
	Total	**1,900**	**5,800**	**9,100**	**TBD**

(In Thousands of $)

		DOE Funding			
No.	**Major Recipient**	**FY 1994**	**FY 1995**	**FY 1996**	**FY 1997**
1	University of Oregon	500	450	400	TBD
2	Florida Solar Energy Center (FSEC)	600	650	700	TBD
3	Pennsylvania State University	50	25	25	TBD
	Total	**1,150**	**1,125**	**1,125**	**TBD**

Q230. Please identify the participants in the Exemplary Residential Buildings Program, including DOE funding to each for the period FY 1994 - FY 1997.

A230. The participants in the Exemplary Buildings Program include: the National Renewable Energy Laboratory, National Park Service, Oz Architecture (Denver, CO), Gary Watt Architecture (Louisville, KY), North Carolina Country Builders (Pittsboro, NC), Tierra Concrete Homes (Pueblo, CO), One Design (Winchester, VA), the Passive Solar Industries Council (PSIC) and the international research community. This list of participants references primarily the design teams and therefore, in some case, does not identify the building owners.

In this program, the Department, through the National Renewable Energy Laboratory (NREL) and, in the case of two buildings, the international research community, provide the design assistance required to integrate advanced concepts into buildings to the building owners' design team. The owner constructs the building, and NREL measures the building's performance to determine whether or not the building functions as anticipated. PSIC with the other industry participants then puts the design and performance information in the form required if the solar/energy efficiency measures used to achieve these high-performing buildings are to be widely used.

All the funding provided for the Residential Exemplary Buildings Program is provided to NREL. That funding is an estimated $250,000 in FY 1994 when the program was being defined, $400,000 in FY 1995, $300,000 planned in FY 1996, and $600,000 required in FY 1997 for replication and subdivision-scale adaptation of advanced concepts used in the Exemplary Buildings now under construction or being measured.

Q231. Please describe "Health Houses", including details of participants and both DOE and private-sector funding for the period FY 1994 - FY 1997.

A231. A description of the "Health Houses," program participants and funding details are described in answer 229. *[Reproduced here.]*

The Orlando Health House '95, of the American Lung Association of Central Florida, opened for a week of public tours on December 8, 1995. This 3,750 square-foot house has been a collaborative program between the DOE EEIH program: FSEC; the American Lung Association of Central Florida: the builder, Scott L. Philpot; Tuscawilla Realty; and *Professional Builder* Magazine to showcase the latest construction techniques and products for creating a living environment that is healthy and energy efficient.

The use of a dehumidification system; high efficiency filters; and a tight duct system in this energy efficient house is intended to eliminate not only pollen and dust but also dust mites, which according to allergists are a leading cause of allergy related illness and asthma in Florida. With the approval of the family purchasing this house, testing will continue for 1-3 years by FSEC in cooperation with the College of Medicine at the University of Southern Florida.

Q232. Please provide a listing of the recipients of (i) the $8,950,000 in funding in FY 1995, (ii) the $10,719,000 in FY 1996 funding, and (iii) the requested level of $16,350,000 in FY 1997 for Commercial Buildings.

Q233. For each recipient of Commercial Buildings funds identified in the response to question 232 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A232 and A233. The recipients and their cost-share are listed in the following table:

Commercial Planning Unit
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	ORNL*	0			N
2	LBNL*	0			N
3	PNNL*	0			N
4	ANL*	0			N
5	Metropolitan Energy Center Kansas City Partnership	33,000**			Y
6	Mass Energy Effic. Council Rebuild Boston	51,000**			Y
7	Berkeley Energy Service Corp. San Francisco	18,000**			Y
8	State of Tennessee	1,000**			Y
9	State of Wisconsin	21,000**			Y
10	State of Colorado	17,600**			Y
11	California Institute for Energy Efficiency	600	600	TBD	N
12	National Institute of Standards & Technology	300	300	TBD	N
13	United States Conference of Mayors	25	50	TBD	N
14	Toledo, OH Rebuild America Project	30,000			Y
15	Habitat for Humanity	50	50	TBD	N
16	Rebuild FY96 Award Winners	0	75,000		Y

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
17	Portland Energy Conservation Inc.	100		TBD	Y
18	Rebuild FY97 Award Winners			180,000**	N
19	Minneapolis, St. Paul Rebuild America Project	30,000	0	TBD	Y
	Total	202,675	76,000	TBD	

*Cost-share for National Laboratories includes funding from other sources such as other agencies, user fees, etc.
**Cost-share shown is for a 5-year project period.

Q234. For those Commercial Buildings funding recipients identified in the response to question 232 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A234. Justification for non-competitive awards in Commercial Building Planning unit as identified in the table above are as follows:

#1, # 2, #3, #4: Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurement for the management of each laboratory.

#11: California Institute for Energy Efficiency was selected as a private sector partner in the implementation of the Commercial Building–Advanced Buildings for 2005 program based on unique capabilities and contributing partners. This was in lieu of creating these capabilities with in the Federal workforce.

#12: National Institutes of Standards and Technologies (NIST) receives funding through an Interagency Agreement based on unique capabilities consistent with its mission as a federal research resource.

#13: United States Conference of Mayors was selected as an implementation partner with unique capabilities.

#15: Habitat for Humanities was selected as an implementation partner with unique capabilities.

#17: Co-supported by EPA, Portland Energy Conservation receives funding through a non-competitive sub-contract based on their unique capabilities.

Q235. Please identify each of the Rebuild America partnerships, and both DOE and private-sector funding to each partnership for the period FY 1994 - FY 1997.

A235. There were no partners and no appropriations for this program in FY 1994. The program began in FY 1995. Funding and cost sharing for the partnerships is shown below.

(In Thousands of $)

FY95	**DOE**	**Private**
Rebuild Boston Energy Initiative	763	51,000*
Kansas City Energy Efficiency Partnership	496	33,000*
San Francisco Bay Area E.E. Consortium	1,292	18,000*
State of Wisconsin	990	21,000*
State of Colorado	202	17,600*
State of Tennessee	556	1,000*
Total, 1995	**4,298**	**$141,600**
FY96		
Minneapolis/St. Paul, MN	750	30,000*
Toledo, OH	700	30,000*
Five new Awardees	2,500	75,000**
Total, 1996	**3,950**	**$135,000**
FY97		
12 New Awardees	6,000	$180,000**

* Cost-share shown is for a five year project period and are actual amounts specified in the awardee's proposal.

** Cost-share amounts shown are projections based on FY95 partnership cost-share ratios.

Q236. Please provide a listing of the recipients of (i) the $4,827,000 in funding in FY 1995, (ii) the $4,444,000 in FY 1996 funding, and (iii) the requested level of $8,739,000 in FY 1997 for Best Practices.

Q237. For each recipient of Best Practices funds identified in the response to question 236 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A236 and A237. The recipients and their cost-share are listed in the following table:

Best Practices Business Unit
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	NREL*	0	0	TBD	N
2	LBNL* (Tools)	1,050	1,050	TBD	N
3	LBNL* (IAQ)	0	0	TBD	N
4	PNNL* (Tools)	350	750	TBD	N
5	Construction Engineering Research Labs	0	200	TBD	N
6	United Technology Research Center	100	0	TBD	N
7	Air Infiltration Ventilation Centre (IEA)	450	450	TBD	Y
8	Passive Solar Industries Council	66	222	TBD	N

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
9	NIST/IAQ	0	0	TBD	N
10	Southeast Energy Institute	600	0	TBD	N
11	Quantum Inc.	100	0	TBD	N
	Total	2,716	2,672	TBD	

*Cost-share for National Laboratories and the Construction Engineering Research Laboratories includes funding from other sources such as other agencies, user fees, etc.

Q238. For those Commercial Buildings funding recipients identified in the response to question 236 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A238. Justification for non-competitive awards in Best Practices Planning unit as identified in the table above are as follows:

#1, # 2, #3, #4: Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurement for the management of each laboratory.

#5: The Construction Engineering Research Laboratories receives funding through a Interagency Agreement. Justification is based on the desire of both Agencies to consolidate 25 years of experience in energy performance simulation into a single focused effort.

#6: Through their own initiative United Technology Research Center availed themselves of the unique research capabilities at NREL through the CRADA process.

#8: Passive Solar Industries Council receives funding through a non-competitive subcontract based on their unique capabilities.

#9: National Institutes of Standards and Technologies (NIST) receives funding through an Interagency Agreement based on unique capabilities at NIST consistent with their mission as a federal research resource.

#10: Southface was selected on the basis of an unsolicited proposal, the sole source justification was based on unique capabilities.

#11: Quantum Inc. availed themselves of the unique research capabilities at LBNL through the cooperative agreement process.

Q239. Please provide a detailed list of activities funded by Best Practices Information and Outreach and Technical Support for the period FY 1994-1997, including a listing of each recipient of these funds.

A239. Activities include development and dissemination of print and non-print media materials as well as exhibits and conference support which cross the technologies and research of the buildings research programs. The recipients of these funds are the laboratories

(Brookhaven National Laboratory, National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory) where the buildings research is conducted.

Q240. For those Best Practices Information and Outreach and Technical Support funding recipients identified in the response to question 239 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A240. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurement for the management of each laboratory.

Building Equipment and Materials

Q241. Page 370 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Space Conditioning R&D:

	2000	2010	2020
Primary Energy Saved (TBtu/yr)	**50**	**299**	**978**
Energy Cost Savings (Millions 1993$)	**330**	**2,360**	**8,420**
Carbon Reductions (MMT carbon equiv.)	**0.95**	**6.24**	**21.14**

Q241a. Please provide detailed documentation of each of these claimed benefits.

A241a. All programs for which BTS is requesting funding have been assigned to one of nine planning units to simplify cross-sector comparisons and restrict to a manageable number the elements being evaluated. Benefits estimates appearing in the Budget Request are assessed at the planning unit level.

The Space Conditioning R&D Planning Unit consists of the following programs:

- Thermally Activated Heat Pumps: GAX Heat Pump
- Thermally Activated Heat Pumps: Hi-Cool Heat Pump
- Thermally Activated Heat Pumps: Large Commercial Chiller
- Advanced Desiccant Technology
- Advanced Refrigeration Systems (Adv. Heat Pump)
- Technology Introduction Partnerships/Space Conditioning
- Solar Building Technology (SDHW)

The benefits are estimated at a program level and then aggregated to yield planning unit level benefits. Energy cost savings and carbon equivalent emissions reductions are computed from the energy savings.

Most of the programs in this planning unit target specific types of space conditioning equipment within a building. Equipment programs are characterized by a new equipment efficiency. The Thermally Activated Heat Pumps: GAX Heat Pump (TAHP: GAX) program is used to illustrate the fairly involved calculation methodology.

In the calculations, a set of baseline input estimates are used for all programs. The inputs have been divided into five categories: building stock, end-use loads, equipment market shares, equipment efficiencies, and replacement factors.

Building Stock

Building stock estimates are used to estimate the total energy savings at the national level for each program. The stock estimates have been developed for each market segment (building type, building vintage, and region) based on the following assumptions:

- 60% of the existing building stock is in the north.
- 40% of the existing building stock is in the south.
- New stock is divided evenly across regions.
- 0.6% annual degradation rate for existing residential buildings.
- 0.5% annual degradation rate for existing commercial buildings.

Residential and Commercial existing building stock totals for the years 1990, 2000, 2005, and 2010 were provided by AEO 1995. Total stock for the years 2015 and 2020 are extrapolated from the 2010 stock number using the growth rate for the years 2005-2010.

The model assumes that the existing stock degrades at a constant rate of 0.6% per year for residential buildings and 0.5% for commercial buildings. New stock is then calculated as the difference between the total stock as reported in AEO and the existing stock. Through the use of the assumptions listed above, the building stocks are segmented by building vintage and region. The base year is 1995, and all construction after 1995 is considered "new."

Disaggregation of the building stock into "north" and "south" regions was accomplished by using the EIA climate zones published in CBECS and RECS. Climate zones 1-3 (those zones with more than 4,000 heating-degree days) were designated as the "north" region, and zones 4 and 5 (those zones with less than 4,000 heating-degree days) were defined as the "south" region. Using this method, approximately 60% of the buildings are located in the north and 40% in the south. The split is assumed to remain constant throughout the analysis period, as the degradation rates are assumed to be equal across regions. It was assumed that new buildings would be split equally between the regions (50% north and 50% south) based on the pattern observed in the 1980s.

End-Use Loads

End-use load estimates are used to determine the existing load per unit (households for residential, square foot for commercial) for heating, cooling, and water heating so that energy savings due to the program being analyzed can be determined. The end-use loads are developed from loads generated by the DOE2 simulation model and have been developed for each market segment (building type, building vintage, and region). To separate the loads into "north" and "south" a weighted average was developed by using CBECS climate zones 1-3 for the north and 4-5 for the south.

Residential Loads: Residential heating and cooling loads were taken from an LBL study conducted in 1992 (Hanford and Huang 1992). In the analysis, building characteristics that were located in a Gas Research Institute (GRI) database were combined with component load values created by running DOE-2 simulations. Heating and cooling load results from DOE-2 were reduced to a set of regression coefficients that describe the contribution of each building component to overall building heating and cooling load. Building loads were then scaled by the building populations represented by each of building prototype populations. Four average buildings were defined: north/existing, north/new, south/existing, and south/new. Component loads were calibrated to the simulated building loads from the GRI database. National aggregate heating and cooling loads as reported in the GRI database were apportioned across buildings types by dividing the calculated load in each category by the population of buildings in the category.

Commercial Loads: Commercial heating and cooling load estimates are based on simulations of retail and office buildings using DOE-2.1d. To represent new buildings, the simulation models were set to minimal compliance levels for the ASHRAE Standard 90.1-1989. For existing buildings, a second set of simulation models were constructed that complied with the envelope requirements of ASHRAE Standard 90-75/90A 1980. The simulations were performed on three, three-story building types: retail, office, and other ("other" is a composite of 50% office and 50% retail).

Existing Buildings: Data from AEO 1992 was used to derive total heating and cooling consumption per square foot (kBtu/SF). Heating is the sum of gas, oil, electricity, and other. The national average heating and cooling loads that were derived from the DOE-2 simulations are used to create an adjustment factor that is designed to align the model with AEO estimates (AEO estimates were divided by DOE-2 estimate). Lastly, the DOE-2 north and south load estimates are adjusted by multiplying them by the adjustment factors.

New Buildings: It was assumed that new buildings are, on average, 20% more efficient for heating, and 10% more efficient for cooling than existing buildings.

Existing Equipment Market Shares

Equipment market shares are broken out by market segment and are estimated from CBECS, RECS, and original PNL efforts by Dave Belzer.

Equipment Efficiencies

The efficiency of equipment stock is developed from Annual Energy Outlook, 1994 (AEO, 1994) and input from program managers. Where applicable, the assumed stock efficiency increased to meet equipment standards.

Replacement Factors

Equipment replacement factors are used in the calculation of the number of units representing the potential target market for programs targeting specific pieces of equipment. It is assumed that BTS technologies compete only with "new" units. For new buildings, all units are considered new; thus, the replacement factor for equipment in new buildings is 1.0. For existing buildings, only those units that are scheduled for replacement are considered eligible for the BTS technology. In other words, it is assumed that the BTS technology does not replace a piece of equipment unless the equipment was going to be replaced anyway. The replacement factor for existing buildings for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1998 to 2000; the factor for 2005 represents the turnover percentage from 2001 to 2005, etc.). The replacement factors are based on the specific equipment's life expectancy.

Calculation Methodology

The steps involved in calculating the energy savings associated with TAHP: GAX are:

- Determine size of potential market.
- Determine number of units affected by BTS program.
- Determine base space conditioning energy consumption.
- Determine space conditioning energy consumption after program implementation.
- Calculate energy savings.

These steps are discussed below.

Determine Size of Potential Market

The TAHP: GAX program targets residential buildings in the north (both new and existing buildings) with gas furnaces and electric central air conditioners. The size of this potential market is determined by the building stock, existing equipment market share, and replacement of existing stock. Table 241.1 shows the northern residential building stock, in millions of households, and is part of the baseline assumptions. The stock of new buildings is defined as those built within the period (e.g., 2.40 million households are expected to be built in the north between 1998 and 2000); not the total new building stock (all buildings built since 1995). The existing building stock is defined as the total stock in existence in that year. The cumulative number of buildings represents the total building stock in existence (new plus existing).

Table 241.2 contains the existing equipment market shares, defined as part of the baseline assumptions set. Because the program targets only specific pieces of equipment, only that portion of the whole market can be penetrated by the program. The building stock is multiplied by the market share for gas furnaces and electric central air conditioners to determine the equipment stock (Table 241.3).

The final component needed to calculate the installed units is the replacement factor (Table 241.4). It is assumed that the BTS technology competes only with "new" units. For new buildings, all units are considered new. For existing buildings, only those units that are scheduled for replacement are considered eligible for the BTS technology. In other words, it is assumed that the BTS technology does not replace a piece of equipment unless the equipment was going to be replaced anyway. Because new buildings require new equipment, the replacement factor is 1.0. For existing buildings, the replacement factor for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1997 to 2000, the factor for 2005 represents the turnover percentage from 2000 to 2005, etc.). The replacement factor is multiplied by the equipment stock to yield the total equipment sales, which represents the potential target market for this program (see Table 241.5).

Determine Number of Units Affected by the BTS Program

The number of units affected-by the BTS program is calculated using the equipment sales (Table 241.5) and the program penetration rates (Table 241.6). The penetration rates into the gas furnace market differ from the penetration rates into the electric CAC market because the market shares for those equipment types are different. In order to replace the same number of units (a gas furnace and an electric CAC) with a GAX heat pump, the penetration into the gas heating market is determined, and then the penetration into the electric cooling market is back-calculated from the estimated number of installed units.

The penetration rates are multiplied by the equipment sales to determine the number of installed units (see Table 241.7). For both the new and existing building stock, this figure represents the number of installed units within that period, and not the cumulative number. Because energy savings are accumulated over time–a unit installed in 2000 will continue to save energy throughout its life–the number of installed units must be summed to represent the total number of installed units in the given year (see Table 241.8). Thus, the total number of installed units listed for 2010 in Table 241.7 (0.60) represents the number installed between 2005 and 2010, while the corresponding number in Table 241.8 (0.85) represents the number of units installed since the program was implemented. Unlike the envelope program calculations, where existing building installed units were not summed, existing building units for equipment programs are summed because the use of the replacement factor introduces the element of period replacement.

Determine Base Space Conditioning End-Use Loads

The next step in the process is to determine the baseline energy consumption. For equipment programs, the baseline consumption is represented by the existing heating and cooling end-use loads and is calculated using baseline assumptions about end-use heating and cooling loads and existing equipment efficiencies. The end-use loads for residential building heating and cooling are presented in Table 241.9, and are part of the baseline assumptions. Because these represent the average end-use loads, they are divided by the equipment efficiency (see Table 241.10) for each equipment type targeted by the BTS program to determine the actual building level baseline consumption in the target market, as shown in Table 24 1.11.

The building consumption is translated into regional consumption by multiplying it by the cumulative installed units for that region (given in Table 241.8). The regional consumption is presented by end-use in Table 241.12.

Determine Space Conditioning End-Use Loads After Program Implementation

The next step in the process is to determine the energy consumption once the program has been implemented. This calculation is similar to the baseline energy calculation, except the new equipment efficiencies are used. The end-use loads for residential building heating and cooling are presented in Table 241.9, and are part of the baseline assumptions. Because these represent the average end-use loads, they are divided by the new equipment efficiency (see Table 241.13) for each equipment type targeted by the BTS program to determine the actual building level baseline consumption in the target market, as shown in Table 241.14.

The building level consumption is translated into regional consumption by multiplying it by the cumulative installed units for that region (given in Table 241.8). The regional consumption is presented by end-use in Table 241.15.

Calculate Energy Savings

The energy savings are calculated from the regional consumption tables in three parts: savings resulting from the change in gas heating equipment, electricity savings resulting from switching fuels to gas, and a natural gas dissavings resulting from the use of gas as the cooling fuel. Table 241.16 contains the actual energy savings from the BTS program. The savings calculated in Table 241.16 are aggregated by fuel type to determine the total delivered electric savings, total primary electric savings (equal to total delivered electric multiplied by an electricity conversion ratio of 3.019), total natural gas savings, total oil savings, and total primary savings. The energy savings are presented in Table 241.17.

Because the energy savings calculations are based on performance and penetration inputs specific to the program's FY 1996 budget goals, they must be adjusted to account for changes between the FY 1996 budget request and the FY 1997 budget request. Table 241.18 presents the budget requests for FY 1996 and FY 1997. The ratio of FY97 to FY96 is multiplied by the total primary energy savings to yield the total primary budget adjusted savings presented in Table 241.19.

Calculate Energy Cost Savings

The energy cost savings are calculated using the energy savings by fuel (Table 241.19) and fuel prices (Table 241.20). The fuel prices are applied to the corresponding energy savings by fuel (the electricity price is multiplied by the estimate of delivered electricity) to yield the consumer cost savings presented in Table 241.21.

Calculate Carbon Equivalent Emissions Reductions

The carbon reductions are calculated using the energy savings by fuel (Table 241.19) and the carbon coefficients (Table 241.22). The carbon coefficients are applied to the corresponding energy savings by fuel (the electricity coefficient is applied to the primary electricity estimate) to yield the carbon
reductions presented in Table 241.23.

[Note: Tables 241.1-17 referred in the answer to Q242a are attached following the answer to Q241b. DOE did not provide Tables 241.18-23.]

Q241b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A241b. The building sector is typically averse to engaging in research activities that possess high levels of either technical or economic risk, except under extremely unusual circumstances (risk being defined here as the likelihood of failure in realizing sufficient returns on R&D investment). This is at least partly due to the disaggregate nature of the industry (e.g., the largest home builder in America controls less than 1% of the market), which means that the relative size of investment needed to perform R&D is too large for most individual companies to even produce, much less "risk." The buildings market also tends to be conservative in terms of acceptance rates of advanced technologies. These and other factors tend to slow the rate of technology innovation in the buildings sector. even though many buildings technologies offer significant benefits in terms of energy, environmental, or national security issues. DOE activities address risk of a technical or economic nature, and are aimed at reducing it through one form or another until the remaining risk is within acceptable limits of the buildings sector.

Technical risk can be reduced by advancing the technology or enabling technologies through research and development, and is usually focused on technical performance improvement. Economic risk can also be reduced through research and development (e.g., developing alternative component materials that are much less costly than their predecessors), but may also be reduced by sharing the costs (i.e., risk) of R&D through either direct support or through helping spread them across multiple R&D partners. Economic risk can also be reduced by addressing the market in ways that are impractical for individual member companies in the private sector, such as playing the role of an independent third-party evaluator (e.g., as in product efficiency labeling). Some specific program examples from Space Conditioning R&D follow:

GAX Heat Pump: Prior to DOE's solicitation in 1981, there was no extensive research underway in ammonia/water absorption heat pump systems for the residential sector. The technical challenge was considerable and energy prices favored electrical heat pump systems. However, earlier development work sponsored by DOE had proven that absorption technology was technically feasible, but required significantly further development to be economically feasible. This work is nearing completion today, and an industrial partner is assuming more development responsibility as DOE transitions out.

Advanced Gas Cooling: Advanced gas cooling systems, e.g., desiccants, still possess a fair degree of both technical and economic risk in terms of widespread application, even though several manufacturers are building systems designed for niche markets. For example, there currently exists no reliable methodology for comparing performance of desiccant systems from different manufacturers for a particular application each manufacturer wants to portray their system in its best light, and so performance measurements and claims are not necessarily made on a consistent basis. Part of DOE's current effort in desiccant systems is to establish a performance database to help prospective users evaluate the true potential of a desiccant-based system for their application.

Alternative Refrigerants: DOE helped form a Consortium of industry partners to develop alternatives to chlorofluorocarbon refrigerants, as a direct result of the Montreal Protocol phaseout of these chemicals, that resulted in a much faster response by industry than would have been possible had the partners pursued these avenues separately. To quote a letter from Ted Rees, President of the Air-Conditioning & Refrigeration Institute, referring to the greatly increased positive balance of trade for that industry:

> "One important factor in this time period has been U.S. manufacturers' ability to move quickly away from CFCs to alternative refrigerants. The DOE-supported MCLR program has played a large part in this quick response . . . resulting in measurable benefits to U.S. industry and the U.S. economy . . ."

Technology Introduction Partnerships (TIPS): DOE works through "Energy Saver Partnerships" and other collaborative relationships to facilitate the identification and development of initial markets for high efficiency equipment, and to reduce manufacturing costs through better product design and economies of scale in initial production. The Super-Efficient Refrigerator Program accomplishes a similar objective. The effect of these programs is to overcome a "chicken and egg" problem where manufacturers cannot afford the risk of investing in large-scale production of new technologies without assured markets, while consumers refrain from buying in large quantifies until costs of the technologies come down.

A second role TIPS programs play is as an impartial source of technical expertise for firms, the hotel and motel industry, which are not technically-oriented and which consider energy to be outside of their main line of business. Through such efforts, DOE enables these firms to make sound investment decisions, thereby lowering costs, becoming more competitive, and providing the best possible services to their customers. Third and finally, in meetings to organize an efficiency labeling program to identify better than minimum standard appliances, retailers explicitly indicated that the labels needed the DOE imprimatur to be effective in their stores. Without it, they maintain, such labels appear to consumers as just another advertising claim with substantially less credibility.

In conclusion, DOE activities address the various types of risk associated with any research and development endeavor, and provide a host of complementary services that would be otherwise unavailable to the private sector. Although it can never be said with certainty (as with any future projection) that the benefits of these activities would never be achieved in DOE's absence, the evidence strongly suggests that this is the case, or that they would be significantly delayed at the very least. The societal benefits derived from these activities warrant a Federal role in encouraging them.

APPENDIX TABLES FOR QUESTION 241.a

Table 241.1 **Building Stock** **Units:** Million households

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.75	1.60	2.40	4.20	4.40	4.75	4.75
Residential	Existing	North	57.66	56.77	55.44	53.04	50.40	47.31	44.22
Residential		Total	58.41	58.37	57.84	57.24	54.80	52.06	48.97
Residential		Cumulative	58.41	59.12	60.19	61.99	63.75	65.41	67.07

Table 241.2 **Existing Equipment Market Shares** **Units:** % of Households

Table 241.2a **Vintage:** New

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	21.8%	21.8%	21.7%	21.6%	19.0%	18.7%	18.3%
Space Heating	Electricity	Forced Air	19.7%	20.1%	20.4%	20.9%	21.6%	21.6%	21.6%
Space Heating	Gas	Furnace	32.7%	31.4%	30.1%	27.3%	23.6%	23.5%	23.4%
Space Heating	Oil	Furnace	11.0%	11.0%	10.9%	10.8%	10.7%	10.7%	10.7%
Space Cooling	Electricity	Heat Pump	20.3%	20.3%	20.2%	20.2%	18.0%	18.0%	18.0%
Space Cooling	Electricity	Central Air	59.2%	58.2%	57.1%	55.2%	52.5%	52.5%	52.4%

Table 241.2b **Vintage:** Existing

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%
Space Heating	Electricity	Forced Air	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%
Space Heating	Gas	Furnace	59.3%	59.3%	59.3%	59.3%	59.3%	59.3%	59.3%
Space Heating	Oil	Furnace	18.7%	18.7%	18.7%	18.7%	18.7%	18.7%	18.7%
Space Cooling	Electricity	Heat Pump	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%
Space Cooling	Electricity	Central Air	91.3%	91.3%	91.3%	91.3%	91.3%	91.3%	91.3%

Table 241.3 **Equipment Stock** **Units:** Million households

Table 241.3a **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.25	0.50	0.72	1.15	1.04	1.12	1.11
Residential	Existing	North	34.19	33.66	32.88	31.45	29.89	28.05	26.22

Table 241.3b **Equipment:** Electric Central Air Conditioning

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.44	0.93	1.37	2.32	2.31	2.49	2.49
Residential	Existing	North	52.64	51.83	50.62	48.43	46.02	43.19	40.37

Table 241.4 **Replacement Factors** **Units:** New Equipment Purchases as a % of Equipment Stock

Table 241.4a **Building Type:** Residential New

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Space Heating	Electricity	Forced Air	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Space Heating	**Gas**	**Furnace**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Space Heating	Oil	Furnace	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Space Cooling	Electricity	Heat Pump	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Space Cooling	**Electricity**	**Central Air**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**

Table 241.4b **Building Type:** Residential Existing

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	0.0350	0.0700	0.1050	0.1750	0.1750	0.1750	0.1750
Space Heating	Electricity	Forced Air	0.0350	0.0700	0.1050	0.1750	0.1750	0.1750	0.1750
Space Heating	**Gas**	**Furnace**	**0.0350**	**0.0700**	**0.1050**	**0.1750**	**0.1750**	**0.1750**	**0.1750**
Space Heating	Oil	Furnace	0.0350	0.0700	0.1050	0.1750	0.1750	0.1750	0.1750
Space Cooling	Electricity	Heat Pump	0.0350	0.0700	0.1050	0.1750	0.1750	0.1750	0.1750
Space Cooling	**Electricity**	**Central Air**	**0.0350**	**0.0700**	**0.1050**	**0.1750**	**0.1750**	**0.1750**	**0.1750**

Table 241.5 **Equipment Sales** **Units:** Million Households

Table 241.5a **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.25	0.50	0.72	1.15	1.04	1.12	1.11
Residential	Existing	North	1.20	2.36	3.45	5.50	5.23	4.91	4.59

Table 241.5b **Equipment:** Electric Central Air Conditioning

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.44	0.93	1.37	2.32	2.31	2.49	2.49
Residential	Existing	North	1.84	3.63	5.31	8.47	8.05	7.56	7.07

Table 241.6 **Penetration Rates** **Units:** % of equipment sales in period

Table 241.6a **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00%	0.00%	1.00%	7.00%	12.00%	23.50%	35.00%
Residential	Existing	North	0.00%	0.00%	0.00%	3.00%	9.00%	24.50%	40.00%

Table 241.6b **Equipment:** Electric Central Air Conditioning

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00%	0.00%	0.53%	3.46%	5.39%	10.51%	15.63%
Residential	Existing	North	0.00%	0.00%	0.00%	1.95%	5.85%	15.91%	25.98%

Table 241.7 **Installed Units (New in Period)** **Units:** Million households

Table 241.7a **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.01	0.08	0.12	0.26	0.39
Residential	Existing	North	0.00	0.00	0.00	0.17	0.47	1.20	1.84
		Total	0.00	0.00	0.01	0.25	0.60	1.47	2.22

Table 241.7b **Equipment:** Electric Central Air Conditioning

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.01	0.08	0.12	0.26	0.39
Residential	Existing	North	0.00	0.00	0.00	0.17	0.47	1.20	1.84
		Total	0.00	0.00	0.01	0.25	0.60	1.46	2.22

Table 241.8 **Cumulative Installed Units** **Units:** Million households

Table 241.8a **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.01	0.09	0.21	0.47	0.86
Residential	Existing	North	0.00	0.00	0.00	0.17	0.64	1.84	3.67
		Total	0.00	0.00	0.01	0.25	0.85	2.31	4.54

Table 241.8b **Equipment:** Electric Central Air Conditioning

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.01	0.09	0.21	0.47	0.86
Residential	Existing	North	0.00	0.00	0.00	0.17	0.64	1.84	3.67
		Total	0.00	0.00	0.01	0.25	0.85	2.31	4.54

Table 241.9 **End-Use Loads** **Units:** MBtu/HH/Year

Table 241.9a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	43.10	43.10	43.10	43.10	43.10	43.10	43.10
Residential	Existing	North	57.90	57.90	57.90	57.90	57.90	57.90	57.90

Table 241.9b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	8.80	8.80	8.80	8.80	8.80	8.80	8.80
Residential	Existing	North	9.20	9.20	9.20	9.20	9.20	9.20	9.20

Table 241.10 **Existing Equipment Efficiencies**

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Space Heating	Electricity	Forced Air	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Space Heating	**Gas**	**Furnace**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**	**0.78**
Space Heating	Oil	Furnace	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Space Cooling	Electricity	Heat Pump	2.93	2.93	2.93	2.93	2.93	2.93	2.93
Space Cooling	**Electricity**	**Central Air**	**2.93**	**2.93**	**2.93**	**2.93**	**2.93**	**2.93**	**2.93**

Table 241.11 **Building Level Baseline Consumption** **Units:** MBtu/HH/Year

Table 241.11a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	55.26	55.26	55.26	55.26	55.26	55.26	55.26
Residential	Existing	North	74.23	74.23	74.23	74.23	74.23	74.23	74.23

Table 241.11b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Residential	Existing	North	3.14	3.14	3.14	3.14	3.14	3.14	3.14

Table 241.12 **Regional Baseline Consumption** **Units:** TBtu/Year

Table 241.12a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	5	12	26	48
Residential	Existing	North	0	0	0	12	47	136	273

Table 241.12b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	1	3
Residential	Existing	North	0	0	0	1	2	6	12

Table 241.13 **Performance Inputs** **Units:** New Equipment Efficiency

Table 241.13a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	1.60	1.60	1.60	1.60	1.80	1.80	1.80
Residential	Existing	North	1.60	1.60	1.60	1.60	1.80	1.80	1.80

Table 241.13b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.70	0.70	0.70	0.70	0.80	0.80	0.80
Residential	Existing	North	0.70	0.70	0.70	0.70	0.80	0.80	0.80

Table 241.14 **Building Level New Consumption** **Units:** MBtu/HH/Year

Table 241.14a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	26.94	26.94	26.94	26.94	23.94	23.94	23.94
Residential	Existing	North	36.19	36.19	36.19	36.19	32.17	32.17	32.17

Table 241.14b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	12.57	12.57	12.57	12.57	11.00	11.00	11.00
Residential	Existing	North	13.14	13.14	13.14	13.14	11.50	11.50	11.50

Table 241.15 **Regional New Consumption** **Units:** TBtu/Year

Table 241.15a **End-Use:** Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	2	5	11	21
Residential	Existing	North	0	0	0	6	20	59	118

Table 241.15b **End-Use:** Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	2	5	9
Residential	Existing	North	0	0	0	2	7	21	42

Table 241.16 **Actual Energy Savings** **Units:** Tbtu/Year

Table 241.16a **Equipment:** Gas Furnace to Residential Absorption Heat Pump

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	2	7	15	27
Residential	Existing	North	0	0	0	6	27	77	155

Table 241.16b **Equipment:** Electric Central Air to Residential Absorption Heat Pump (Electricity Savings)

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	1	3
Residential	Existing	North	0	0	0	1	2	6	12

Table 241.16c **Equipment:** Electric Central Air to Residential Absorption Heat Pump (Natural Gas Savings)

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	(0)	(1)	(2)	(5)	(9)
Residential	Existing	North	0	0	0	(2)	(7)	(21)	(42)

Table 241.17 **Energy Savings, All Equipment Types and End-Uses** Units: Tbtu/Year

Table 241.17a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	1	3
Residential	New	South	0	0	0	1	2	6	12
Total			0	0	0	1	3	7	14

Table 241.17b **Primary Electricity** **Electricity Conversion Ratio:** 3 019

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	2	4	8
Residential	New	South	0	0	0	2	6	17	35
Total			0	0	0	2	8	22	43

Table 241.18 **Budget Adjustment**

FY 96 Budget Request:	3.9 million $
FY 97 Budget Request:	3.7 million $

Table 241.19 **Budget Adjusted Energy Savings, All Equipment Types and End-Uses** **Units:** Tbtu/Year

Table 241.19a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	1	1	2
Residential	New	South	0	0	0	0	2	5	11
Total			0	0	0	1	2	7	13

Table 241.19b **Primary Electricity** **Electricity Conversion Ratio:** 3.019

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	2	4	7
Residential	New	South	0	0	0	1	6	17	33
Total			0	0	0	2	8	21	40

Table 241.19c **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	1	4	9	17
Residential	New	South	0	0	0	4	18	53	107
Total			0	0	0	5	23	62	123

Table 241.19d **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	0	0	0
Residential	New	South	0	0	0	0	0	0	0
Total			0	0	0	0	0	0	0

Table 241.19e **Total Primary**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	2	6	13	24
Residential	New	South	0	0	0	5	24	70	140
Total			0	0	0	7	30	83	164

Table 241.20 **Fuel Prices** **Units:** 1995 $ / MBtu

Building Type	Fuel Type	1995	1997	2000	2005	2010	2015	2020
Residential	Electricity	24.82	24.95	25.15	26.36	27.64	28.15	28.66
Residential	Natural Gas	6.46	6.45	6.44	7.16	7.48	8.16	8.89
Residential	Oil	7.07	7.46	8.06	8.55	9.05	9.57	10.13

Table 241.21 **Consumer Cost Savings** **Units:** Million 1995 $

Table 241.21a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	1	7	17	38	70
Residential	New	South	0	0	0	13	52	154	314
Total			0	0	1	20	69	192	384

Table 241.21b **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	1	9	31	75	148
Residential	New	South	0	0	0	28	138	435	947
Total			0	0	1	37	168	510	1,095

Table 241.21c **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	0	0	0	0	0
Residential	New	South	0	0	0	0	0	0	0
Total			0	0	0	0	0	0	0

Table 241.21d **Total**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0	0	1	16	47	113	218
Residential	New	South	0	0	0	41	190	589	1,261
Total			0	0	1	57	238	702	1,479

Table 241.22 **Carbon Coefficients** **Units:** MM Tons / QBtu

Fuel Type	Coefficient
Electricity	22.32
Natural Gas	14.69
Oil	19.65

Table 241.23 **Carbon Equivalent Emissions Reductions** **Units:** MM Ton / Year

Table 241.23a **Primary Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.02	0.04	0.09	0.17
Residential	New	South	0.00	0.00	0.00	0.03	0.13	0.37	0.74
Total			0.00	0.00	0.00	0.05	0.17	0.46	0.90

Table 241.23b **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.02	0.06	0.13	0.24
Residential	New	South	0.00	0.00	0.00	0.06	0.27	0.78	1.57
Total			0.00	0.00	0.00	0.08	0.33	0.92	1.81

Table 241.23c **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residential	New	South	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total			0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 241.23d **Total**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Residential	New	North	0.00	0.00	0.00	0.04	0.10	0.23	0.41
Residential	New	South	0.00	0.00	0.00	0.09	0.40	1.15	2.30
Total			0.00	0.00	0.00	0.13	0.50	1.38	2.71

Q242. Please provide a listing of the recipients of (i) the $13,107,000 in funding in FY 1995, (ii) the $9,895,000 in FY 1996 funding, and (iii) the requested level of $12,313,000 in FY 1997 for Space Conditioning R&D.

Q243. For each recipient of Space Conditioning R&D funds identified in the response to question 242 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A242 and A243. The recipients of the funding for Space Conditioning in FY 1995 through FY 1997 are shown in the table below, as well as cost-sharing provided by each recipient for FY 1995 - FY 1997.

Space Conditioning R&D Recipients and Cost-Share*
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Air Conditioning & Refrigeration Technology Institute (ARTI)	84	33	TBD	N
2	Oak Ridge National Laboratory	90	522	TBD	N
3	University of Maryland	10	100	TBD	N
4	Electric Power Research Institute	0	100	TBD	N
5	Carrier Corporation	940	634	TBD	N
6	York International	167	200	TBD	Y
7	ICC-Englehard/Carrier	267	0	TBD	Y
8	SEMCO/Trane	133	0	TBD	Y
9	Brookhaven National Laboratory	10	100	TBD	N
10	Energy Concepts	0	0	TBD	Y
11	RA Technologies	0	0	TBD	Y
12	Battelle Columbus	0	0	TBD	Y
13	Phillips Engineering	0	0	TBD	Y
14	Rocky Research	0	0	TBD	Y
15	NIST	250	250	TBD	N
	Total	**1,951**	**1,939**	**TBD**	

* Cost-share for National Laboratories includes funding from other sources such as user fees, etc.

Q244. For those Space Conditioning R&D funding recipients identified in the response to question 242 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A244. The recipients of non-competitive awards for Space Conditioning R&D funds are identified in the table for the response to question 242, above. A justification for the each non-competitive award is provided in the following table:

No.	Major Recipient	Justification
1	Air Conditioning & Institute (ARTI)	Recipient of a multi-year grant award based on acceptance of an unsolicited proposal; unique representation of industry in a pre-competitive R&D consortium.
2	Oak Ridge National Laboratory	Laboratory funding is based on a determination by DOE Laboratory project manager(s) that Laboratory staff are uniquely qualified to accomplish work assignments. The Laboratory's relationship with the Department is set by the M&O contracts awarded through competitive procurement for the management of each Laboratory.
3	University of Maryland	Recipient of a multi-year grant based on acceptance of an unsolicited proposal; unique laboratory and personnel to conduct R&D on electrohydrodynamics.
4	Electric Power Research Institute (EPRI)	Funding is based on the unique capabilities as a national Institute (EPRI) R&D organization for electric utilities, and by significant cost-sharing for the project.
5	Carrier Corporation	Justification based on Carrier obtaining an exclusive world-wide license from Phillips Engineering, a small business, to develop the Generator Absorber Heat Exchange (GAX) technology. Phillips was granted the patent rights from the Department of Energy.
9	Brookhaven National Laboratory	Laboratory funding is based on a determination by DOE Laboratory project manager(s) that Laboratory staff are uniquely qualified to accomplish work assignments. The Laboratory's relationship with the Department is set by the M&O contracts awarded through competitive procurement for the management of each Laboratory.
15	NIST	Interagency agreement between DOE and NIST for refrigeration research.

Q245a. Please describe the Gas Industry Consortium and identify its members, and costs of membership in the Consortium.

A245a. The Gas Industry Consortium is made up of gas companies and the Gas Research Institute (GRI), who have assembled to assist in the development and commercialization of the Generator Absorber Heat Exchange (GAX) absorption heat pump for residential and light commercial applications. Members of the Gas Industry Consortium participate by directly funding DOE's manufacturing partner to develop the GAX heat pump, along with DOE. Membership in the consortium and individual contributions consist of:

Columbus Gas	$500,000
NYGAS	$500,000
Southern California Gas Company	$500,000
Brooklyn Union Gas	$360,000
Gas Natural (Spain)	$500,000
Gas Research Institute	$2,000,000
Total	**$4,360,000**

Q245b. Please describe the contractual or other formal legal instruments currently existing between the DOE and the Gas Industry Consortium, including cost-sharing and intellectual property agreements.

A245b. There are no contractual or other formal legal instruments existing between DOE and the consortium.

Q246. Please describe in detail the "technology transfer and commercialization effort with Carrier and major gas utilities" (page 375 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request)* since its inception, and provide DOE and private-sector funding, by fiscal year, for this effort.

A246. The technology transfer and commercialization effort referred to in the FY 1997 budget request is part of DOE's program to commercialize the Generator Absorber Heat Exchange (GAX) absorption heat pump technology with Carrier. The objective of the "technology transfer and commercialization effort" is to transfer the GAX technology from Phillips Engineering and Oak Ridge National Laboratory, and assist in training Carrier technical personnel in ammonia/water advance cycle absorption heat pumps. A senior staff engineer from Oak Ridge National Laboratory is assigned to Carrier to assist in transferring the GAX technology. Technology transfer is an integral part of the programs. Since it is not separately funded or costed, we are unable to provide the breakout requested. However, funding for the entire GAX program is shown in the following table:

GAX Program Funding
(In Thousands of $)

	FY 1994	**FY 1995**	**FY 1996**	**FY 1997**	**FY 1998**	**Total**
Private Sector	550	374	528	594	594	2,640
DOE	2,500	1,700	2,400	2,700	2,700	12,000
Total	**3,050**	**2,074**	**2,928**	**3,294**	**3,294**	**14,640**

Q247. Page 370 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Lighting and Appliance R&D:

	2000	**2010**	**2020**
Primary Energy Saved (TBtu/yr)	**134**	**824**	**1755**
Energy Cost Savings (Millions 1993$)	**960**	**6,620**	**15,100**
Carbon Reductions (MMT carbon equiv.)	**2.88**	**18.06**	**38.52**

Q247a. Please provide detailed documentation of each of these claimed benefits.

A247a. The Lighting and Appliance R&D Planning Unit consists of the following programs:

- VHF Light Sources (Low Power S-Lamps).
- Electronics (Hi Power S-Lamps).
- Fixtures/Distribution Systems (CFL).
- New Concepts (Halo-en IR).
- Lighting Impacts (Scotopic).

- Technology Introduction Partnerships/Appliances.

The technologies in this planning unit target lighting in buildings. Lighting programs are characterized by a change in efficacy (lumens per watt). *The Electronics (Hi-Power S-Lamps) program is used to illustrate the calculation methodology.*

In the calculations, a set of baseline input estimates are used for all programs. The inputs have been divided into five categories: building stock, end-use loads, equipment market shares, equipment efficiencies, and replacement factors.

Building Stock

Building stock estimates are used to estimate the total energy savings at the national level for each program. The stock estimates have been developed for each market segment (building type, building vintage, and region) based on the following assumptions:

- 60% of the existing building stock is in the north.
- 40% of the existing building stock is in the south.
- New stock is divided evenly across regions.
- 0.6% annual degradation rate for existing residential buildings.
- 0.5% annual degradation rate for existing commercial buildings.

Residential and Commercial existing building stock totals for the years 1990, 2000, 2005, and 2010 were provided by AEO 1995. Total stock for the years 2015 and 2020 are extrapolated from the 2010 stock number using the growth rate for the years 2005-2010.

The model assumes that the existing stock degrades at a constant rate of 0.6% per year for residential buildings and 0.5% for commercial buildings. New stock is then calculated as the difference between the total stock as reported in AEO and the existing stock. Through the use of the assumptions listed above, the building stocks are segmented by building vintage and region. The base year is 1995, and all construction after 1995 is considered new

Disaggregation of the building stock into “north” and “south” regions was accomplished by using the EIA climate zones published in CBECS and RECS. Climate zones 1-3 (those zones with more than 4,000 heating-degree days) were designated as the “north” region, and zones 4 and 5 (those zones with less than 4,000 heating-degree days) were defined as the “south” region. Using this method, approximately 60% of the buildings are located in the north and 40% in the south. The split is assumed to remain constant throughout the analysis period, as the degradation rates are assumed to be equal across regions. It was assumed that new buildings would be split equally between the regions (50% north and 50% south) based on the pattern observed in the 1980s.

End-Use Loads

End-use load estimates are used to determine the existing load per unit (households for residential, square foot for commercial) for heating, cooling, and water heating so that energy savings due to the program being analyzed can be determined. The end-use loads are developed from loads generated by the DOE-2 simulation model and have been developed for each market segment (building type, building vintage. and region). To separate the loads into "north" and "south" a weighted average was developed by using NBECS climate zones 1-3 for the north and 4-5 for the south.

Residential Loads: Residential heating and cooling loads were taken from an LBL study conducted in 1992 (Hanford and Huang 1994). In the analysis, building characteristics that were located in a Gas Research Institute (GRI) database were combined with component load values created by running DOE-2 simulations. Heating and cooling load results from DOE-2 were reduced to a set of regression coefficients that describe the contribution of each building component to overall building heating and cooling load. Building loads were then scaled by the building populations represented by each of building prototype populations. Four average buildings were defined: north/existing, north/new, south/existing, and south/new. Component loads were calibrated to the simulated building loads from the GRI database. National aggregate heating and cooling loads as reported in the GRI database were apportioned across buildings types by dividing the calculated load in each category by the population of buildings in the category. Commercial Loads Commercial heating and cooling load estimates are based on simulations of retail and office buildings using DOE-2.1d. To represent new buildings, the simulation models were set to minimal compliance levels for the ASHRAE Standard 90.1-1989. For existing buildings, a second set of simulation models were constructed that complied with the envelope requirements of ASHRAE Standard 90-75/90A-1980. The simulations were performed on three, three-story building types: retail, office, and other ("other" is a composite of 50% office and 50% retail).

Existing Buildings: Data from AEO 1992 was used to derive total heating and cooling consumption per square foot (kBtu/SF). Heating is the sum of gas, oil, electricity, and other. The national average heating and cooling loads that were derived from the DOE-2 simulations are used to create an adjustment factor that is designed to align the model with AEO estimates (AEO estimates were divided by DOE-2 estimate). Lastly, the DOE-2 north and south load estimates are adjusted by multiplying them by the adjustment factors.

New Buildings: It was assumed that new buildings are, on average, 20% more efficient for heating, and 10% more efficient for cooling than existing buildings.

Existing Equipment Market Shares

Equipment market shares are broken out by market segment and are estimated from CBECS, RECS, and original PNL efforts by Dave Belzer.

Equipment Efficiencies

The efficiency of equipment stock is developed from Annual Energy Outlook, 1994 (AEO, 1994) and input from program managers. Where applicable, the assumed stock efficiency increased to meet equipment standards.

Replacement Factors

Equipment replacement factors are used in the calculation of the number of units representing the potential target market for programs targeting specific pieces of equipment. It is assumed that OBT technologies compete only with "new" units. For new buildings, all units are considered new; thus, the replacement factor for equipment in new buildings is I.O. For existing buildings, only those units that are scheduled for replacement are considered eligible for the OBT technology. In other words, it is assumed that the OBT technology does not replace a piece of equipment unless the equipment was going to be replaced anyway. The replacement factor for existing buildings for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1998 to 2000; the factor for 2005 represents the turnover percentage from 2001 to 2005, etc.). The replacement factors are based on the specific equipment's life expectancy.

Calculation Methodology

The steps involved in calculating the energy savings associated with Hi-Power S-Lamps are:

- Determine base lighting energy consumption.
- Determine unit energy savings.
- Determine size of potential market.
- Determine number of units affected by OBT program.
- Calculate lighting energy savings.
- Calculate interactive effects.
- Calculate energy savings.

These steps are discussed below.

Determine Base Lighting Consumption

The first step in the process is to determine the baseline energy consumption. The consumption for commercial building lighting is presented in Table 247.1, and is part of the baseline assumptions. The performance improvements for lighting programs are characterized by changes in lighting efficacy. It is therefore not necessary to explicitly calculate base energy consumption. Instead, the change in efficacy is applied to the base lighting consumption to determine the energy savings.

Determine Lighting Energy Savings

The performance improvements for lighting programs are characterized by changes in lighting efficacy. The existing equipment efficacies are presented in Table 247.2, and the lighting efficacy for the Hi-Power S-Lamp (HPSL) is presented in Table 247.3.

Energy savings are calculated using an efficacy ratio, defined as:

Efficacy Ratio = 1-(Base Efficacy/OBT Efficacy).

The efficacy ratios for HPSL relative to their target market, HID lamps, is presented in Table 247.4. The change in efficacy is multiplied by the base lighting consumption (Table 247.1) to determine the potential annual energy savings in kWh per square foot, presented in Table 247.5. The potential energy savings are translated to kBtu per square foot in Table 247.6.

The energy savings in Table 247.6 represent the possible savings per square foot of commercial floorspace if all commercial HIDs were replaced with the HPSL. The actual savings will be determined by the target market and number of units installed, as explained in the following sections.

Determine Size of Potential Market

The Hi-Power S-Lamp program targets HID lighting in commercial buildings (both new and existing buildings). The size of this potential market is determined by the building stock, existing equipment market share, and replacement of existing stock. Table 247.7 presents the commercial building stock, in billions of square feet, and is part of the baseline assumptions. The stock of new buildings is defined as those built within the period (e.g., 2.16 billion square feet are expected to be built in the north between 1998 and 2000); not the total new building stock (all buildings built since 1995). The existing building stock is defined as the total stock in existence in that year.

Table 247.8 contains the existing equipment market shares, defined as part of the baseline assumptions set. Because the program targets only specific pieces of equipment, only that portion of the whole market can be penetrated by the program. The building stock is multiplied by the market share for HID lighting to determine the equipment stock (Table 247.9).

The final component needed to calculate the installed units is the replacement factor (Table 247.10). It is assumed that the OBT technology competes only with "new" units. For new buildings, all units are considered new. For existing buildings, only those units that are scheduled for replacement are considered eligible for the OBT technology. In other words, it is assumed that the OBT technology does not replace a piece of equipment unless the equipment was going to be replaced anyway. Because new buildings require new equipment, the replacement factor is 1.0. For existing buildings, the replacement factor for a given year is based on the percentage of the equipment that is expected to turn over in that period (e.g., the factor for 2000 represents the percentage turnover from 1998 to 2000, the factor for 2005 represents the turnover percentage from 2001 to 2005, etc.). The replacement factor is multiplied by the equipment stock to yield the total equipment sales, which represents the potential target market for this program (see Table 247.11).

Determine Number of Units Affected by the OBT Program

The number of units affected by the OBT program is calculated using the equipment sales (Table 247.11) and the program penetration rates (Table 247.12).

The penetration rates are multiplied by the equipment sales to determine the number of installed units (see Table 247.13). For both the new and existing building stock, this figure represents the number of installed units within that period, and not the cumulative number. Because energy savings are accumulated over time–a unit installed in 2000 will continue to save energy throughout its life–the number of installed units must be summed to represent the total number of installed units in the given year (see Table 247.14). Thus, the total number of installed units listed for 2010 in Table 247.13 (0.50 billion square feet) represents the number installed between 2005 and 2010, while the corresponding number in Table 247.14 (0.87 billion square feet) represents the number of units installed since the program was implemented.

Calculate Lighting Energy Savings

The regional lighting electricity savings are calculated by multiplying the potential annual energy savings (Table 247.6) by the number of installed units (Table 247.14). This yields the lighting savings, as presented in Table 247.15.

Calculate Interactive Effects

Changes in lighting technologies have an effect on the heating and cooling systems within a building. These interactive effects must therefore be calculated and included in the energy savings estimate. Table 247.16 presents the interactive effects factors by end-use and fuel type for the commercial market sector. These factors are multiplied by the regional lighting savings presented in Table 247.15 to determine the changes in loads associated with the OBT technology. The regional interactive load reductions are presented in Table 247.17.

The regional interactive load reductions must be translated into regional interactive energy savings. To do this, baseline assumptions regarding existing equipment efficiencies and existing equipment market shares are used. First, the regional load reductions are divided by the baseline existing equipment efficiencies (listed in Table 247.18). This yields potential energy savings by equipment type and end-use, shown in Table 247.19.

The potential interactive energy savings assume that each equipment type has 100% of the market share, so the actual equipment market shares must then be applied. The baseline existing equipment market shares are presented in Table 247.20. The market share for each equipment type is multiplied by the potential interactive energy savings calculated in Table 247.19 to determine the actual energy savings, presented in Table 247.21.

Calculate Energy Savings

The savings calculated in Tables 247.15 and 247.21 are aggregated by fuel type to determine the total delivered electric savings, total primary electric savings (equal to total delivered electric multiplied by an electricity conversion ratio of 3.019), total natural gas savings, total oil savings, and total primary savings. The energy savings are presented in Table 247.22.

Because the energy savings calculations are based on performance and penetration inputs specific to the program's FY 1996 budget goals, they must be adjusted to account for changes between the FY 1996 budget request and the FY 1997 budget request. Table 247.23 presents the budget requests for FY 1996 and FY 1997. The ratio of FY97 to FY96 is multiplied by the total primary energy savings to yield the total primary budget adjusted savings presented in Table 247.24.

Calculate Energy Cost Savings

The energy cost savings are calculated using the energy savings by fuel (Table 247.24) and fuel prices (Table 247.25). The fuel prices are applied to the corresponding energy savings by fuel (the electricity price is multiplied by the estimate of delivered electricity) to yield the consumer cost savings presented in Table 247.25.

Calculate Carbon Equivalent Emissions Reductions

The carbon reductions are calculated using the energy savings by fuel (Table 247.24) and the carbon coefficients (Table 247.26). The carbon coefficients are applied to the corresponding energy savings by fuel (the electricity coefficient is applied to the primary electricity estimate) to yield the carbon reductions presented in Table 247.27.

Q247b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A247b. It is not possible to state with absolute certainty that the predicted benefits associated with the Department's Lighting and Appliance R&D program would not occur without the proposed DOE funding. In all likelihood, some of the technologies and programs proposed by the Department would eventually come to fruition without Federal support, while others almost surely would not. However, the stimulus and timing of the proposed DOE funding is necessary to achieve the estimated magnitude and timing of the energy savings stated. Two examples are presented to support this position.

Proposed funding for the **Technology Introduction Partnerships program** will be used to accelerate the adoption of high performance appliances through a coordinated effort involving the nation's large retail chains, manufacturers, utilities, commercial establishments, and homebuilders. The Department is in a unique position as the only entity capable of bringing disparate groups of stakeholders together toward a common goal of increasing the adoption rate of advanced appliance technology. In one case, a collaborative partnership established between the Department, manufacturers of an innovative filtering technology, and a major hotel chain will test and verify the energy and water savings associated with a high efficiency laundry water filtration and recycling system. The credibility of DOE as an unbiased third party in assessing this technology's costs and benefits proved important to the formation of the collaborative and, if the technology proves itself in the DOE cost-shared demonstration, it will be quickly adopted by several hotel/motel chains throughout the U.S. and other commercial operations where large amounts of laundry facilities operate. Without DOE involvement the hotel/motel industry was not been willing to invest the effort and capital necessary to install and test this unproven technology, and it may have taken several more years before its benefits could be verified to the satisfaction of potential users.

Proposed funding is also being applied in support of **scotopic lighting research** that would not be carried out at all without DOE support. Most lighting manufacturers are not equipped to conduct scientific research at the fundamental level represented by scotopics, and it would be difficult to accept human factors-related research performed by the manufacturers as unbiased. By supporting highly qualified and equipped university researchers, the Department can pursue the potentially significant benefits in both worker productivity and energy performance that would accrue from optimum spectrum light sources. Once the benefits are established as credible, the lighting industry should respond favorably to the concept and take the next steps to bring scotopic lighting to the market.

The likelihood of private industry undertaking these projects without DOE co-sponsorship was addressed also by *Corporate R&D in Transition: Changing Patterns of Private Sector Investment in Research and Development*, U.S. Department of Energy, March 1996. This comprehensive study of private sector research trends found that private sector investment in R&D has broken from past growth trends. In 1995, real company R&D spending fell for the third consecutive year–the first time this has happened in over forty years. The study found that industry's R&D priorities have shifted away from basic and applied research to emphasize less creative, near-term product development to support the market strategies and bottom lines of their business units.

APPENDIX TABLES FOR QUESTION 247.A

Table 247.1 Annual Base Lighting Consumption Units: kWh/SF/Year

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	4.48	4.33	4.18	3.98	3.85	3.60	3.34
Commercial	New	South	4.48	4.33	4.18	3.98	3.85	3.60	3.34
Commercial	Existing	North	4.48	4.33	4.18	3.98	3.85	3.60	3.34
Commercial	Existing	South	4.48	4.33	4.18	3.98	3.85	3.60	3.34

Table 247.2 Existing Equipment Efficiencies Units: lum/watt

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Lighting	Electricity	EE Fluor	62.00	62.00	62.00	62.00	62.00	62.00	62.00
Lighting	Electricity	EE Incan	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Lighting	**Electricity**	**HID**	**69.00**	**69.00**	**69.00**	**69.00**	**69.00**	**69.00**	**69.00**
Lighting	Electricity	Std Fluor	59 00	59.00	59.00	59 00	59.00	59.00	59.00
Lighting	Electricity	Std Incan	18 00	18.00	18 00	18 00	18.00	18.00	18.00

Table 247.3 Performance Inputs Units: lum/watt

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Commercial	New	South	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Commercial	Existing	North	135 00	135.00	135.00	135.00	135.00	135.00	135.00
Commercial	Existing	South	135 00	135.00	135.00	135 00	135.00	135.00	135.00

Table 247.4 Efficacy Ratios

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0 49	0.49	0.49	0.49	0.49	0.49	0.49
Commercial	New	South	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Commercial	Existing	North	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Commercial	Existing	South	0 49	0.49	0.49	0.49	0.49	0.49	0.49

Table 247.5 **Annual Energy Savings** **Units:** kWh/SF/Year

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	2.19	2.12	2.04	1.95	1.88	1.76	1.63
Commercial	New	South	2.19	2.12	2.04	1.95	1.88	1.76	1.63
Commercial	Existing	North	2.19	2.12	2.04	1.95	1.88	1.76	1.63
Commercial	Existing	South	2.19	2.12	2.04	1.95	1.88	1.76	1.63

Table 247.6 **Annual Energy Savings** **Units:** kBtu/SF/Year

Conversion Factor: 3.413 kBtu/kWh

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	7.48	7.22	6.97	6.64	6.42	6.00	5.57
Commercial	New	South	7.48	7.22	6.97	6.64	6.42	6.00	5.57
Commercial	Existing	North	7.48	7.22	6.97	6.64	6.42	6.00	5.57
Commercial	Existing	South	7.48	7.22	6.97	6.64	6.42	6.00	5.57

Table 247.7 **Building Stock** **Units:** Billion Square Feet

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.70	1.44	2.16	3.70	3.85	3.98	3.98
Commercial	New	South	0.70	1.44	2.16	3.70	3.85	3.98	3.98
Commercial	New	All	1.40	2.88	4.32	7.40	7.70	7.96	7.96
Commercial	New	Cumulative	1.40	4.28	8.60	16.00	23.70	31.66	39.62
Commercial	Existing	North	40.20	39.43	38.28	35.64	32.88	30.24	27.60
Commercial	Existing	South	26.80	26.29	25.52	23.76	21.92	20.16	18.40
Commercial	Existing	All	67.00	65.72	63.80	59.40	54.80	50.40	46.00
		Total	68.40	70.00	72.40	75.40	78.50	82.06	85.62

Table 247.8 **Existing Equipment Market Shares** **Units:** % of Square Feet

Building Type: Commercial

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Lighting	Electricity	EE Fluor	31.2%	31.2%	31.2%	31.2%	31.2%	31.2%	31.2%
Lighting	Electricity	EE Incan	12.1%	12.1%	12.1%	12.1%	12.1%	12.1%	12.1%
Lighting	**Electricity**	**HID**	**3.8%**	**3.8%**	**3.8%**	**3.8%**	**3.8%**	**3.8%**	**3.8%**
Lighting	Electricity	Std Fluor	27.6%	27.6%	27.6%	27.6%	27.6%	27.6%	27.6%
Lighting	Electricity	Std Incan	25.3%	25.3%	25.3%	25.3%	25.3%	25.3%	25.3%

Table 247.9 **Equipment Stock** **Units:** Billion Square Feet

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.03	0.05	0.08	0.14	0.14	0.15	0.15
Commercial	New	South	0.03	0.05	0.08	0.14	0.14	0.15	0.15
Commercial	Existing	North	1.51	1.48	1.44	1.34	1.24	1.14	1.04
Commercial	Existing	South	1.01	0.99	0.96	0.89	0.83	0.76	0.69

Table 247.10 **Replacement Factors** **Units:** New Equipment Purchases as a % of Equipment Stock

Table 247.10a **Building Type:** Commercial New

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Lighting	Electricity	EE Fluor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Lighting	Electricity	EE Incan	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Lighting	**Electricity**	**HID**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Lighting	Electricity	Std Fluor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Lighting	Electricity	Std Incan	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 247.10b **Building Type:** Commercial Existing

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Lighting	Electricity	EE Fluor	0.0600	0.1200	0.1800	0.3000	0.3000	0.3000	0.3000
Lighting	Electricity	EE Incan	0.0600	0.1200	0.1800	0.3000	0.3000	0.3000	0.3000
Lighting	**Electricity**	**HID**	**0.0600**	**0.1200**	**0.1800**	**0.3000**	**0.3000**	**0.3000**	**0.3000**
Lighting	Electricity	Std Fluor	0.0600	0.1200	0.1800	0.3000	0.3000	0.3000	0.3000
Lighting	Electricity	Std Incan	0.0600	0.1200	0.1800	0.3000	0.3000	0.3000	0.3000

Table 247.11 **Equipment Sales** **Units:** Billion Square Feet

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.03	0.05	0.08	0.14	0.14	0.15	0.15
Commercial	New	South	0.03	0.05	0.08	0.14	0.14	0.15	0.15
Commercial	Existing	North	0.09	0.18	0.26	0.40	0.37	0.34	0.31
Commercial	Existing	South	0.06	0.12	0.17	0.27	0.25	0.23	0.21

Table 247.12 **Penetration Rates** **Units:** % of Equipment Sales in Period

Equipment: HID

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00%	0.00%	15.00%	30.00%	55.00%	60.00%	65.00%
Commercial	New	South	0.00%	0.00%	15.00%	30.00%	55.00%	60.00%	65.00%
Commercial	Existing	North	0.00%	0.00%	15.00%	30.00%	55.00%	60.00%	65.00%
Commercial	Existing	South	0.00%	0.00%	15.00%	30.00%	55.00%	60.00%	65.00%

Table 247.13 **Installed Units (New in Period)** **Units:** Billion Square Feet

Equipment: HID

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.01	0.04	0.08	0.09	0.10
Commercial	New	South	0.00	0.00	0.01	0.04	0.08	0.09	0.10
Commercial	Existing	North	0.00	0.00	0.04	0.12	0.20	0.20	0.20
Commercial	Existing	South	0.00	0.00	0.03	0.08	0.14	0.14	0.14
		Total	0.00	0.00	0.09	0.28	0.50	0.52	0.53

Table 247.14 **Cumulative Installed Units** **Units:** Billion Square Feet

Equipment: HID

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.01	0.05	0.13	0.22	0.32
Commercial	New	South	0.00	0.00	0.01	0.05	0.13	0.22	0.32
Commercial	Existing	North	0.00	0.00	0.04	0.16	0.36	0.57	0.77
Commercial	Existing	South	0.00	0.00	0.03	0.11	0.24	0.38	0.51
		Total	0.00	0.00	0.09	0.37	0.87	1.40	1.93

Table 247.15 **Regional Lighting Electricity Savings** **Units:** TBtu/Year (Delivered Electric)

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.09	0.36	0.87	1.41	1.96
Commercial	New	South	0.00	0.00	0.09	0.36	0.87	1.41	1.96
Commercial	Existing	North	0.00	0.00	0.27	1.07	2.39	3.61	4.74
Commercial	Existing	South	0.00	0.00	0.18	0.72	1.59	2.41	3.16

Table 247.16 **Interactive Effects Factors**

Building Type	End Use	Fuel Type	1995	1997	2000	2005	2010	2015	2020
Commercial	Heat	Elec	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Commercial	Heat	Gas	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Commercial	Heat	Oil	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Commercial	Cool	Elec	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Commercial	Cool	Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial	Cool	Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 247.17 **Regional Interactive Load Reductions** **Units:** Tbtu/Year

Table 247.17a **End-Use:** Space Heating

Fuel Type: Electric

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	-0.00	-0.01	-0.03	-0.06	-0.08
Commercial	New	South	0.00	0.00	-0.00	-0.01	-0.03	-0.06	-0.08
Commercial	Existing	North	0.00	0.00	-0.01	-0.04	-0.10	-0.14	-0.19
Commercial	Existing	South	0.00	0.00	-0.01	-0.03	-0.06	-0.10	-0.13

Table 247.17b **End-Use:** Space Heating

Fuel Type: Gas

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	-0.00	-0.02	-0.04	-0.07	-0.10
Commercial	New	South	0.00	0.00	-0.00	-0.02	-0.04	-0.07	-0.10
Commercial	Existing	North	0.00	0.00	-0.01	-0.05	-0.12	-0.18	-0.24
Commercial	Existing	South	0.00	0.00	-0.01	-0.04	-0.08	-0.12	-0.16

Table 247.17c **End-Use:** Space Heating

Fuel Type: Oil

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	-0.00	-0.00	-0.01	-0.01	-0.02
Commercial	New	South	0.00	0.00	-0.00	-0.00	-0.01	-0.01	-0.02
Commercial	Existing	North	0.00	0.00	-0.00	-0.01	-0.02	-0.04	-0.05
Commercial	Existing	South	0.00	0.00	-0.00	-0.01	-0.02	-0.02	-0.03

Table 247.17d **End-Use:** Space Cooling

Fuel Type: Electric

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.01	0.05	0.13	0.21	0.29
Commercial	New	South	0.00	0.00	0.01	0.05	0.13	0.21	0.29
Commercial	Existing	North	0.00	0.00	0.04	0.16	0.36	0.54	0.71
Commercial	Existing	South	0.00	0.00	0.03	0.11	0.24	0.36	0.47

Table 247.18 **Existing Equipment Efficiencies**

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Space Heating	Electricity	Forced Air	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Space Heating	Gas	Furnace	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Space Heating	Oil	Furnace	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Space Cooling	Electricity	Heat Pump	2.93	2.93	2.93	2.93	2.93	2.93	2.93
Space Cooling	Electricity	Central Air	2.93	2.93	2.93	2.93	2.93	2.93	2.93

Table 247.19 **Potential Interactive Energy Savings** **Units:** Tbtu/Year

Table 247.19a **Equipment:** Electric Heat Pump

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.01)	(0.02)	(0.03)	(0.04)
Commercial	New	South	0.00	0.00	(0.00)	(0.01)	(0.02)	(0.03)	(0.04)
Commercial	Existing	North	0.00	0.00	(0.01)	(0.02)	(0.05)	(0.07)	(0.10)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.01)	(0.03)	(0.05)	(0.06)

Table 247.19b **Equipment:** Electric Forced Air

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.01)	(0.03)	(0.06)	(0.08)
Commercial	New	South	0.00	0.00	(0.00)	(0.01)	(0.03)	(0.06)	(0.08)
Commercial	Existing	North	0.00	0.00	(0.01)	(0.04)	(0.10)	(0.14)	(0.19)
Commercial	Existing	South	0.00	0.00	(0.01)	(0.03)	(0.06)	(0.10)	(0.13)

Table 247.19c **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.01)	(0.02)	(0.06)	(0.09)	(0.13)
Commercial	New	South	0.00	0.00	(0.01)	(0.02)	(0.06)	(0.09)	(0.13)
Commercial	Existing	North	0.00	0.00	(0.02)	(0.07)	(0.15)	(0.23)	(0.30)
Commercial	Existing	South	0.00	0.00	(0.01)	(0.05)	(0.10)	(0.15)	(0.20)

Table 247.19d **Equipment:** Oil Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.00)	(0.01)	(0.02)	(0.03)
Commercial	New	South	0.00	0.00	(0.00)	(0.00)	(0.01)	(0.02)	(0.03)
Commercial	Existing	North	0.00	0.00	(0.00)	(0.01)	(0.03)	(0.05)	(0.06)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.01)	(0.02)	(0.03)	(0.04)

Table 247.19e **Equipment:** Electric Heat Pump

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.00	0.02	0.04	0.07	0.10
Commercial	New	South	0.00	0.00	0.00	0.02	0.04	0.07	0.10
Commercial	Existing	North	0.00	0.00	0.01	0.05	0.12	0.19	0.24
Commercial	Existing	South	0.00	0.00	0.01	0.04	0.08	0.12	0.16

Table 247.19f **Equipment:** Electric Central Air

End-Use: Space Cooling

Building Type	**Building Vintage**	**Building Region**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
Commercial	New	North	0.00	0.00	0.00	0.02	0.04	0.07	0.10
Commercial	New	South	0.00	0.00	0.00	0.02	0.04	0.07	0.10
Commercial	Existing	North	0.00	0.00	0.01	0.05	0.12	0.19	0.24
Commercial	Existing	South	0.00	0.00	0.01	0.04	0.08	0.12	0.16

Table 247.20 **Existing Equipment Market Shares** **Units:** % of Square Feet

Table 247.20a **Region:** New North

End Use	**Fuel Type**	**Equipment Type**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
Space Heating	Electricity	Heat Pump	24.8%	24.8%	24.8%	24.8%	24.8%	24.8%	24.8%
Space Heating	Electricity	Forced Air	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Space Heating	Gas	Furnace	43.7%	42.4%	41.2%	38.8%	34.6%	31.3%	28.0%
Space Heating	Oil	Furnace	5.0%	5.0%	5.0%	4.9%	4.9%	4.9%	4.9%
Space Cooling	Electricity	Heat Pump	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%
Space Cooling	Electricity	Central Air	75.0%	75.0%	75.0%	75.0%	72.5%	68.8%	65.0%

Table 247.20b **Region:** New South

End Use	**Fuel Type**	**Equipment Type**	**1995**	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**
Space Heating	Electricity	Heat Pump	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%
Space Heating	Electricity	Forced Air	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Space Heating	Gas	Furnace	43.7%	42.5%	41.2%	38.8%	34.6%	31.3%	28.0%
Space Heating	Oil	Furnace	5.0%	5.0%	5.0%	4.9%	4.9%	5.0%	5.0%
Space Cooling	Electricity	Heat Pump	20.3%	20.3%	20.2%	20.2%	18.0%	18.0%	18.0%
Space Cooling	Electricity	Central Air	74.8%	74.8%	74.8%	74.8%	72.3%	68.6%	64.8%

Table 247.20c **Region:** Existing North

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Space Heating	Electricity	Forced Air	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%
Space Heating	Gas	Furnace	63.0%	63.0%	63.0%	63.0%	63.0%	63.0%	63.0%
Space Heating	Oil	Furnace	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%
Space Cooling	Electricity	Heat Pump	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Space Cooling	Electricity	Central Air	83.6%	83.6%	83.6%	83.6%	83.6%	83.6%	83.6%

Table 247.20d **Region:** Existing South

End Use	Fuel Type	Equipment Type	1995	1997	2000	2005	2010	2015	2020
Space Heating	Electricity	Heat Pump	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Space Heating	Electricity	Forced Air	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%
Space Heating	Gas	Furnace	63.0%	63.0%	63.0%	63.0%	63.0%	63.0%	63.0%
Space Heating	Oil	Furnace	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%	14.0%
Space Cooling	Electricity	Heat Pump	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Space Cooling	Electricity	Central Air	83.6%	83.6%	83.6%	83.6%	83.6%	83.6%	83.6%

Table 247.21 **Actual Energy Savings** **Units:** Tbtu/Year

Table 247.21a **Equipment:** Electric Heat Pump

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Commercial	New	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Commercial	Existing	North	0.00	0.00	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)

Table 247.21b **Equipment:** Electric Forced Air

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)
Commercial	New	South	0.00	0.00	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)
Commercial	Existing	North	0.00	0.00	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)

Table 247.21c **Equipment:** Gas Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.01)	(0.02)	(0.03)	(0.04)
Commercial	New	South	0.00	0.00	(0.00)	(0.01)	(0.02)	(0.03)	(0.04)
Commercial	Existing	North	0.00	0.00	(0.01)	(0.04)	(0.10)	(0.15)	(0.19)
Commercial	Existing	South	0.00	0.00	(0.01)	(0.03)	(0.06)	(0.10)	(0.13)

Table 247.21d **Equipment:** Oil Furnace

End-Use: Space Heating

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	New	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	Existing	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)

Table 247.21e **Equipment:** Electric Heat Pump

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.00	0.00	0.01	0.02	0.02
Commercial	New	South	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Commercial	Existing	North	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Commercial	Existing	South	0.00	0.00	0.00	0.01	0.01	0.02	0.02

Table 247.21f **Equipment:** Electric Central Air

End-Use: Space Cooling

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.00	0.01	0.03	0.05	0.07
Commercial	New	South	0.00	0.00	0.00	0.01	0.03	0.05	0.06
Commercial	Existing	North	0.00	0.00	0.01	0.05	0.10	0.15	0.20
Commercial	Existing	South	0.00	0.00	0.01	0.03	0.07	0.10	0.14

Table 247.22 **Energy Savings, All Equipment Types and End-Uses** **Units:** Tbtu/Year

Table 247.22a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	0	0	1	1	2
Commercial	New	South	0	0	0	0	1	1	2
Commercial	Existing	North	0	0	0	1	2	4	5
Commercial	Existing	South	0	0	0	1	2	3	3
Total			0	0	1	3	6	9	12

Table 247.23 **Budget Adjustment**

FY 96 Budget Request:	0.701 million $
FY 97 Budget Request:	0.701 million $

Table 247.24 **Budget Adjusted Energy Savings, All Equipment Types and End-Uses** **Units:** Tbtu/Year

Table 247.24a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	0	0	1	1	2
Commercial	New	South	0	0	0	0	1	1	2
Commercial	Existing	North	0	0	0	1	2	4	5
Commercial	Existing	South	0	0	0	1	2	3	3
Total			0	0	1	3	6	9	12

Table 247.24b **Primary Electricity** **Electricity Conversion Ratio:** 3 019

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	0	1	3	4	6
Commercial	New	South	0	0	0	1	3	4	6
Commercial	Existing	North	0	0	1	3	8	11	15
Commercial	Existing	South	0	0	1	2	5	8	10
Total			0	0	2	8	18	28	37

Table 247.24c **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	New	South	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	South	0	0	(0)	(0)	(0)	(0)	(0)
Total			0	0	(0)	(0)	(0)	(0)	(0)

Table 247.22b **Primary Electricity** **Electricity Conversion Ratio:** 3.019

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	0	1	3	4	6
Commercial	New	South	0	0	0	1	3	4	6
Commercial	Existing	North	0	0	1	3	8	11	15
Commercial	Existing	South	0	0	1	2	5	8	10
Total			0	0	2	8	18	28	37

Table 247.22c **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	New	South	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	South	0	0	(0)	(0)	(0)	(0)	(0)
Total			0	0	(0)	(0)	(0)	(0)	(0)

Table 247.22d **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	New	South	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	South	0	0	(0)	(0)	(0)	(0)	(0)
Total			0	0	(0)	(0)	(0)	(0)	(0)

Table 247.22e **Total Primary**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	0	1	3	4	6
Commercial	New	South	0	0	0	1	3	4	6
Commercial	Existing	North	0	0	1	3	7	11	15
Commercial	Existing	South	0	0	1	2	5	8	10
Total			0	0	2	8	18	27	37

Table 247.24d **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	New	South	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	South	0	0	(0)	(0)	(0)	(0)	(0)
Total			0	0	(0)	(0)	(0)	(0)	(0)

Table 247.24e **Total Primary**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	0	1	3	4	6
Commercial	New	South	0	0	0	1	3	4	6
Commercial	Existing	North	0	0	1	3	7	11	15
Commercial	Existing	South	0	0	1	2	5	8	10
Total			0	0	2	8	18	27	37

Table 247.25 **Fuel Prices** Units: 1995 $ / MBtu

Building Type	Fuel Type	1995	1997	2000	2005	2010	2015	2020
Commercial	Electricity	22.21	22.36	22.59	23.76	24.76	25.18	25.60
Commercial	Natural Gas	5.36	5.39	5.41	6.15	6.50	7.18	7.92
Commercial	Oil	4.82	5.19	5.79	6.26	6.75	7.27	7.82

Table 247.25 **Consumer Cost Savings** Units: Million 1995 $

Table 247.25a **Delivered Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	2	9	22	37	52
Commercial	New	South	0	0	2	9	22	37	51
Commercial	Existing	North	0	0	6	27	62	95	127
Commercial	Existing	South	0	0	4	18	41	63	85
Total			0	0	15	62	148	232	315

Table 247.25b Natural Gas

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	New	South	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	North	0	0	(0)	(0)	(1)	(1)	(2)
Commercial	Existing	South	0	0	(0)	(0)	(0)	(1)	(1)
Total			0	0	(0)	(0)	(0)	(0)	(1)

Table 247.25c Oil

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	New	South	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	North	0	0	(0)	(0)	(0)	(0)	(0)
Commercial	Existing	South	0	0	(0)	(0)	(0)	(0)	(0)
Total			0	0	(0)	(0)	(0)	(0)	(0)

Table 247.25d Total

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0	0	2	9	22	37	51
Commercial	New	South	0	0	2	9	22	36	51
Commercial	Existing	North	0	0	6	26	61	94	125
Commercial	Existing	South	0	0	4	18	41	63	84
Total			0	0	15	62	147	231	314

Table 247.26 Carbon Coefficients Units: MM Tons / QBtu

Fuel Type	Coefficient
Electricity	22.32
Natural Gas	14.69
Oil	19.65

Table 247.27 **Carbon Equivalent Emissions Reductions** **Units:** MM Ton / Year

Table 247.27a **Primary Electricity**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.01	0.03	0.06	0.10	0.14
Commercial	New	South	0.00	0.00	0.01	0.03	0.06	0.10	0.14
Commercial	Existing	North	0.00	0.00	0.02	0.08	0.17	0.25	0.33
Commercial	Existing	South	0.00	0.00	0.01	0.05	0.11	0.17	0.22
Total			0.00	0.00	0.04	0.18	0.40	0.62	0.83

Table 247.27b **Natural Gas**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	New	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	Existing	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total			0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)

Table 247.27c **Oil**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	New	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	Existing	North	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Commercial	Existing	South	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total			0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Table 247.27d **Total**

Building Type	Building Vintage	Building Region	1995	1997	2000	2005	2010	2015	2020
Commercial	New	North	0.00	0.00	0.01	0.03	0.06	0.10	0.14
Commercial	New	South	0.00	0.00	0.01	0.03	0.06	0.10	0.13
Commercial	Existing	North	0.00	0.00	0.02	0.07	0.17	0.25	0.33
Commercial	Existing	South	0.00	0.00	0.01	0.05	0.11	0.17	0.22
Total			0.00	0.00	0.04	0.18	0.40	0.62	0.82

Q248. Please provide a listing of the recipients of (i) the $11,600,000 in funding in FY 1995, (ii) the $7,231,000 in FY 1996 funding, and (iii) the requested level of $15,800,000 in FY 1997 for Lighting and Appliance R&D.

Q249. For each recipient of Lighting and Appliance R&D funds identified in the response to question 248 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A248 and A249. The recipients of the funding for Lighting and Appliance R&D in FY 1995 through FY 1997 are shown in the table below, as well as cost-sharing provided by each recipient for FY 1995 - FY 1997.

Lighting and Appliance R&D Recipients and Cost-Share
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Pacific Northwest National Laboratory	0	0	TBD	N
2	Oak Ridge National Laboratory	0	0	TBD	N
3	Lawrence Berkeley National Laboratory	0	0	TBD	N
4	New York State Energy R&D Authority	0	0	TBD	N
5	Bonneville Power Administration	0	0	TBD	N
6	Nutek (Sweden) (IEA)	42	42	TBD	N
7	National Institute of Standards and Technology	0	0	TBD	N
8	Consortium for Energy Efficiency	460	598	TBD	N
9	AD Little, Inc.	0	0	TBD	Y
10	DeLima Associates	0	0	TBD	8(a)
11	D&R International	0	0	TBD	Y
12	ICF, Incorporated	0	0	TBD	N
13	Electric Power Research Institute	1,000	825	TBD	N
14	National Association of Energy Service Companies	55	50	TBD	N
15	Seattle City Light	0	0	TBD	N
16	University of Wisconsin	0	0	TBD	N
17	Advanced Mechanical Technology, Inc.	0	0	TBD	N
18	American Gas Cooling Center	326	271	TBD	N
19	Potomac Communications	0	0	TBD	Y
20	Oregon Dept. of Energy	0	0	TBD	N
21	Washington Dept. of Energy	0	0	TBD	N
22	American Council for an Energy Efficient Economy	0	0	TBD	N
23	Red Lion Inn & Hotels	99	100	TBD	N
24	Fusion Lighting	4,600	5,500	TBD	N
25	3M (partner, received no direct funding)	750	1,200	TBD	N/A
26	Westinghouse Electronics	600	400	TBD	Y
27	Los Alamos National Laboratory-CRADA	0	2,000	TBD	Y
28	Fixture company partners (no direct funds): Cooper, Prescolite, Lumatech, Cylinear, Shaper	115	380	TBD	N/A
	Total	**8,047**	**11,366**	**TBD**	

Q250. For those Lighting and Appliance R&D funding recipients identified in the response to question 248 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A250. The recipients of non-competitive awards for Lighting and Appliance R&D funds are identified in the table for the response to question 248, above. The justifications for the non-competitive awards are provided below:

National Laboratories. National Laboratory funding is based on a determination by DOE program managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

New York State Energy R&D Authority. Awarded originally to the State of New York based on existing state procurement consortium organized by NY State Energy Office.

Bonneville Power Administration. Funds transferred to cooperating federal agencies.

Nutek. Award to Nutek in accordance with provisions with Annex III agreement with International Energy Agency.

Consortium for Energy Efficiency, Electric Power Research Institute, National Association of Energy Service Companies, American Gas Cooling Center. Awards to these three industry associations were based on their unique representation of industry and utility sector by virtue of broad memberships on a nationwide basis.

ICF Incorporated. Selected by Oak Ridge National Laboratory to assist in implementing market transformation programs, based on extensive and unique experience in developing and implementing similar programs for EPA.

Seattle City Light, American Council for an Energy Efficient Economy. Small contracts awarded to take advantage of unique expertise of specific individuals on the staffs of Seattle City Light and ACEEE.

University of Wisconsin. Small contract to take advantage of unique resources of the University of Wisconsin's Center for Integrated Resource Planning.

Advanced Mechanical Technology, Inc. Advanced Mechanical Technology selected by gas companies supporting other elements of the program to apply gas engine heat pump technology to water heating. Oregon and Washington Departments of Energy. Oregon and Washington Departments of Energy are state agencies uniquely positioned to be instrumental in implementing the E-Rated manufactured housing appliance program.

Red Lion Inns. Selected for technology demonstration site based on unsolicited proposal and offer of cost-sharing.

Fusion Lighting Inc. Fusion Lighting Inc. is the inventor and developer of the sulfur lamp. This large amount of co-funding was raised largely due to the success of the first public demonstrations of the lamp, arranged by DOE, in Oct. 1994. Non-competitive due to Fusion Lighting's status as a small business and because the sulfur lamp is a proprietary technology, no one else can bring it to the market.

3MCorporation. 3M Corporation is developing, with their own funds, the hollow light pipe which uses a proprietary plastic film manufactured by them. These light pipes are ideal for use with the sulfur lamp. DOE sponsorship of sulfur lamp research has caused 3M to increase their internal R&D and manufacturing facilities.

Westinghouse Electronics. Westinghouse Electronics was awarded a DOE NICE-3 competitive award for $500,000 in 1995. Subsequent noncompetitive funding is done to carry on this work for a limited time.

Los Alamos National Laboratory (LANL) CRADA. DOE is funding LANL to develop a new type of lighting and appliance product. LANL has a CRADA with a major U.S. R&D and manufacturing firm. This firm is co-funding a large internal R&D effort to utilize this technology.

Cooper, Prescolite, Lumatech, Cylinear, Shaper. These companies are fixture manufacturers who are developing fixtures for the DOE sponsored sulfur lamp. Except for some technical guidance from DOE's lighting group at Lawrence Berkeley National Laboratory, the cost of developing the fixtures is being borne by each company–they have received no DOE funding.

Q251. Page 370 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Materials and Structures R&D:

	2000	2010	2020
Primary Energy Saved (TBtu/yr)	70	148	227
Energy Cost Savings (Millions 1993$)	460	1,120	1,940
Carbon Reductions (MMT carbon equiv.)	1.28	2.75	4.24

Q251a. Please provide detailed documentation of each of these claimed benefits.

A251a. All programs for which BST is requesting funding have been assigned to one of nine planning units to simplify cross-sector comparisons and restrict to a manageable number the elements being evaluated. Benefits estimates appearing in the Budget Request are assessed at the planning unit level. The Materials and Structures R&D Planning Unit consists of the following programs:

- Building Materials.
- Roofs, Walls and Foundations: Retrofit Insulation.
- Roofs, Walls and Foundations: 30/30 Roofs.
- Roofs, Walls and Foundations: Advanced Wall Insulations.
- Urban Heat Islands/Cool Communities.

The benefits are estimated at a program level and then aggregated to yield planning unit level benefits. Energy cost savings and carbon equivalent emissions reductions are computed from the energy savings. The primary energy savings benefits (in trillion Btu's) for the Materials and Structures R&D Planning Unit, by program are as follows:

Program	2000	2010	2020
Building Materials	1	2	4
Roofs, Walls & Foundations: Retrofit Insulation	34	68	82
Roofs, Walls & Foundations: 30/30 Roofs	35	65	110
Roofs, Walls & Foundations: Advanced Wall Insulations	1	10	23
Urban Heat Islands/Cool Communities	0	3	7
Total	71	148	226

Most of these programs target the building envelope, a whole building design approach, or the total building system, and are modeled as improvements to the building envelope. Envelope programs are characterized by a reduction in space conditioning load due to changes in the building system or envelope. See the answer to Question 220a, where the Building America program is used to illustrate the calculation methodology.

Q251b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A251b. It is not possible to say with 100% certainty that the predicted benefits emanating from the Department's Materials and Structures program would never be achieved without the requested funding. DOE does not make such a claim. We do claim, however, that without the stimulus of DOE funding and, more importantly, the scientific expertise and facilities at the DOE laboratories, benefits associated with improvements in building materials and envelope systems would not be achieved within the time frame specified, and may well not be achieved at all.

For example, low slope roofing systems represent substantial costs to building owners through both energy losses and high maintenance, yet no single industry player is in a position to take on the responsibility for developing improved roof systems. The Department's research efforts include integrating expertise from all of the disparate participants in overall roof system development into projects that are cost-shared with industry participants, and then transferring the results of this work throughout the industry so that the entire building sector can benefit through an acceleration in the process of developing energy efficient solutions to the problem of low slope roof performance and longevity.

As another example, new insulating materials have the potential to significantly improve building energy performance and comfort. However, their development is a high-risk undertaking that industry does not have either the capability or motivation to undertake independently, As a result, there is very little independent effort underway within the U.S. to develop new insulating materials. The Department's proposed funding will be used in two ways:

1. Cost-shared R&D with industry that reduces industry risk associated with the development of new materials such as controllable R-value insulation, CFC-free insulation, and high performance super insulation and contributes the scientific expertise of the researchers at the Department's national laboratories to the development of new insulating materials;

2. Develop and test advanced insulating materials at the highly sophisticated laboratory facilities available at the Oak Ridge National Laboratory. These facilities are also operated as a National User Facility which is available for use by industry in testing and evaluation advanced building materials.

Through these cost-shared R&D efforts and the use of Federal laboratory facilities, the Department believes that it is significantly accelerating the introduction of advanced insulating materials into the marketplace, with resultant benefits to building occupants both in terms of energy cost savings and improved comfort levels.

Q252. Please provide a listing of the recipients of (i) the $3,687,000 in funding in FY 1995, (ii) the $3,168,000 in FY 1996 funding, and (iii) the requested level of $3,900,000 in FY 1997 for Materials and Structures R&D.

Q253. For each recipient of Materials and Structures R&D funds identified in the response to question 252 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A252 and A253. The recipients of the funding for Materials and Structures R&D in FY 1995 through FY 1997 are shown in the table below, as well as cost-sharing provided by each recipient for FY 1995 - FY 1997.

Materials and Structures R&D Recipients and Cost-Share
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Oak Ridge National Laboratory*	0	0	TBD	N
2	Lawrence Berkeley National Laboratory* (Urban Heat Islands)	2,000	3,000	TBD	N
3	Lawrence Berkeley National Laboratory*	0	0	TBD	N
4	PPG Industries	180	0	TBD	N
5	Appliance Research Consortia	200	200	TBD	N
6	DuPont/VacuPanel	95	95	TBD	N
7	Aladin Industries	0	75	TBD	N
8	Cellulose IMA	60	60	TBD	N
9	SPI/PIMA (Insulation Industries) CRADA	130	130	TBD	N
10	Building Envelope ResearchCenter Users (including smaller CRADAs)	450	500	TBD	N
11	NIST	0	0	TBD	N
12	Honeywell	0	0	TBD	N
13	University of Minnesota	0	0	TBD	N
14	University of Tennessee	0	0	TBD	N

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
15	University of Colorado	0	0	TBD	N
	Total	3,115	4,060	TBD	

*Cost -share for National Laboratories includes funding from other sources such as other agencies, user fees, etc.

Q254. For those Materials and Structures R&D funding recipients identified in the response to question 252 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A254. Justification for non-competitive awards in Materials and Structures Planning unit as identified in the table above are as follows:

#1, # 2, #3: Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurement for the management of each Laboratory.

#4, #5, #6. #7, #8: Are industry partners on the insulation materials topic selected on a non-competitive basis based on unique capabilities.

#9, #10: Are partners for the Building Envelope Research Center. Through their own initiative these partners availed themselves of the unique research capabilities at ORNL through the CRADA process.

#11: National Institutes of Standards and Technologies (NIST) receives funding through an Interagency Agreement based on unique capabilities at NIST consistent with its mission as a federal research resource.

#12: Honeywell is a subcontractor with unique capabilities in the insulation materials area.

#13, #14, and #15: Are universities that received subcontracts based on unique capabilities.

Q255. Please describe the Building Envelope Research Center (page 390 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request)*, and provide DOE and private-sector funding, by fiscal year, for this effort since its inception.

A255. The Building Envelope Research Center is a key component of the consolidation of Government/industry partnerships at the Oak Ridge National Laboratory. This consolidation is now called the Buildings Technology Center (BTC) and covers topics of building equipment, existing building research, technology transfer, as well as building envelopes and materials. The Center provides the U.S. buildings and appliance industries with broad access to a unique combination of testing and analytical capabilities at ORNL. The special focus of the BTC is a systems approach to the development and validation testing of cost-effective, energy efficient, and environmentally acceptable building and building equipment technologies. The BTC makes available ORNL expertise and facilities to private sector.

BTC facilities are available to manufacturers, universities, or private individuals world-wide for the conduct of proprietary or non-proprietary research. Cooperative research and development agreements (CRADAs) at the BTC have included the participation of such companies and agencies as Dow Chemical, DuPont, AlliedSignal, the Association of Home Appliance Manufacturers, the Environmental Protection Agency, Clayton Homes, Dow Coming, and the National Roofing Contractors Association. To date, more than 200 private users have taken advantage of the facility under 30 separate agreements.

The centerpiece test facility is the Large-Scale Climate Simulator where large roof sections are sandwiched between two environmental chambers. The upper climate chamber simulates any outdoor weather condition on earth; the lower metering chamber models interior conditions. Researchers use the Rotatable Guarded Hot Box to test full-size wall fenestration, roof, and floor systems. The Roof Thermal Research Apparatus has eight replaceable roof panels, four replaceable wall panels, and a controlled interior. Two calibrated slab-foundation edges measure thermal performance of slab-on-grade insulation systems.

The Envelope Systems Research Apparatus resembles a residential basement topped with a typical commercial low-sloped roof. It is used to study energy and moisture flow through walls, foundations, and roofs. Since it's inception in FY 1993 and through FY 1995 the center has garnered $1,426,000 in cost shared funding from industry partners. The government share for the development and maintenance of the center was $300,000. In FY 1996 industry partners are contributing $2,085,000 with a government match of $175,000. $700,000 of industry cost share has already been identified for FY 1997.

Q256. Page 370 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Windows and Glazings R&D:

	2000	2010	2020
Primary Energy Saved (TBtu/yr)	**43**	**345**	**807**
Energy Cost Savings (Millions 1993$)	**300**	**2,730**	**6,930**
Carbon Reductions (MMT carbon equiv.)	**0.91**	**7.3**	**17.09**

Q256a. Please provide detailed documentation of each of these claimed benefits.

A256a. All programs for which BST is requesting funding have been assigned to one of nine planning units to simplify cross-sector comparisons and restrict to a manageable number the elements being evaluated. Benefits estimates appearing in the Budget Request are assessed at the planning unit level.

The Windows and Glazings Planning Unit consists of the following programs:

- Electrochromic Research.
- Superwindows Technologies/Collaborative.

- Advanced Glazing.

The benefits are estimated at a program level and then aggregated to yield planning unit level benefits. Energy cost savings and carbon equivalent emissions reductions are computed from the energy savings. The primary energy savings benefits (in trillion Btu's) for the Windows and Glazings Planning Unit, by program are as follows:

Program	2000	2010	2020
Electrochromic Research	0	33	150
Superwindows Technologies/Collaborative	34	229	460
Advanced Glazing	11	84	196
Total	45	346	806

Most of these programs target the building envelope, a whole building design approach, or the total building system, and are modeled as improvements to the building envelope. Envelope programs are characterized by a reduction in space conditioning load due to changes in the building system or envelope. **Please see the answer to Question 220a**, where the Building America program is used to illustrate the calculation methodology.

Q256b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A256b. It is, of course, impossible to say with 100% certainty that the predicted benefits would never be achieved without the Department of Energy (DOE) funding. DOE does not make such a claim. We do claim, however, that without the stimulus of DOE funding, benefits at the magnitude predicted would not be achieved within the time frame specified. If electrochromic glazing and super windows should be developed and commercialized without the proposed DOE support, these events would occur much slower than will be the case with the proposed DOE participation.

An earlier product provides a precedent that supports the credibility of this claim. The development and commercialization of low-E glazing was stimulated by funding from the Windows and Glazing program. Low-E glazing provides a reasonable model for considering the development of electrochromic glazing and super window technologies. Two key events, both directly influenced by DOE investments, moved the development and commercialization of low-E forward in the late 1970s and early 1980s.

DOE funding directly resulted in the first firm (Suntek, later renamed Southwall) offering low-E windows for sale. The company came to DOE for R&D funds when it was unable to obtain private sector investment for its R&D because it was a small company and its technology was seen as unproven and too risky. After three years of Federal support for its R&D efforts, the company was able to raise the venture capital needed to complete production engineering and ultimately to procure of its first low-E coating machine.

The first major window manufacturer to adopt low-E technology was Andersen Windows, who utilized low-E coated glass produced by Cardinal IG, a major U.S. glass manufacturer. Both Anderson and Cardinal stated that DOE-funded efforts in the late 1970s and early 1980s were important factors in the critical decisions that led them to make major capital investments in these new coating technologies at that time.

Q257. Please provide a listing of the recipients of (i) the $4,967,000 in funding in FY 1995, (ii) the $5,936,000 in FY 1996 funding, and (iii) the requested level of $9,170,000 in FY 1997 for Windows and Glazings R&D.

Q258. For each recipient of Windows and Glazings R&D funds identified in the response to question 257 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A257 and A258. The recipients of the funding for Windows and Glazings R&D in FY 1995 through FY 1997 are shown in the table below, as well as cost-sharing provided by each recipient for FY 1995 - FY 1997.

Windows and Glazings R&D Recipients and Cost-Share
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	National Renewable Energy Laboratory*	0	0	0	N
2	Oak Ridge National Laboratory*	0	0	TBD	N
3	Lawrence Berkeley National Laboratory*	0	0	TBD	N
4	Pacific Northwest National Laboratory*	0	0	TBD	N
5	National Fenestration Research Council (NFRC)	1,000	1,000	TBD	N
6	University of Massachusetts	40	35	TBD	N
7	Florida Solar Energy Center	100	100	TBD	N
8	Tufts University	0	N/A	TBD	Y
9	OCLI	300	291	TBD	Y
10	Donnelly Corp.	600	412	TBD	Y
11	Enermodal Corp.	0	N/A	TBD	N
	Total	**2,040**	**1,838**	**TBD**	

*Cost-share for National Laboratories includes funding from other sources such as other agencies, user fees, etc.

Q259. For those Windows and Glazings R&D funding recipients identified in the response to question 257 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A259. Justification for noncompetitive awards in Windows and Glazing planning unit as identified in the table above are as follows:

#1, # 2, #3, #4: Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurement for the management of each Laboratory.

# 5: The National Fenestration Research Council (NFRC) is specified in EPACT

#6&#7: University research grants–sole source justified based on unique capabilities.

#11: Small business sole source justified based on unique research capability.

Codes and Standards

Q260. Page 402 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Building Standards and Guidelines "[a]t the proposed funding levels":

	1997	2000	2010	2020
Total Primary Energy Displaced (TBtu/yr)	56	226	1,027	3,037
Total Energy Cost Savings (Millions $1995)	338	1,582	8,112	26,105
Carbon Equiv. Emissions Reductions (MMtons)	1.18	4.71	21.54	65.30

Q260a. Please provide detailed documentation of each of these claimed benefits.

A260a. The Building Standards and Guidelines energy savings result from the implementation of building codes and standards. Based on the experience of others, programmatic options to reduce energy consumption and greenhouse-gas emissions can be broken into two basic categories: increasing the stringency of building energy codes (e.g. increased savings potential through upgrading voluntary codes), and increasing the adoption and code compliance (e.g., increased code adoption and compliance indices through supporting state and local government code upgrades). **Table 260.1** illustrates the range of options that exist for each category.

Two reference scenarios were developed to represent the impacts of current policy options. These scenarios are based on the AEO 1994 base case and adjusted to include the effects of current policy actions that were not accounted for in the EIA's baseline. The assumed standards that will be in effect for the reference case are listed in **Table 260.2.**

The lower bound of the potential effects of current programs assumes that voluntary code and standard development processes proceed on their historic 7- to 10-year major revision cycle. It also assumes a rate of code adoption and enforcement that is slightly greater than historical code adoption and enforcement. **Table 260.3** depicts the assumptions used in this estimate.

The upper bound of the potential effects of current programs also assumes that the voluntary code and standard development processes proceed on their historic 7- to 10-year major revision cycle. It departs from the lower bound case in assuming a higher rate of code adoption and enforcement by State and local Government. **Table 260.4** depicts the assumptions used in this estimate.

To determine the impacts of energy codes, a baseline must be set from which improvements can be measured. In this analysis, a baseline was determined based on historical practices of builders building to code levels within 15 years of a codes development.

Private Cost Assumptions

Private sector capital cost assumptions vary for residential and commercial codes. The Private Sector Costs assume that the entire cost for building a home that exceeds 1995 baseline construction practice is accounted for. That means that a home built in the year 2010 will bear 100% of the cost of code compliance, plus the cost to reach current practice in the year 2010. This is consistent with the savings estimates that similarly account for the incremental improvement in current practice plus the code improvement. Incremental Private Sector Costs only account for the incremental cost of meeting code from that years current practice. For example, the incremental cost of a home in to meet code in the year 2010 is the cost difference from current practice in 2010 to code levels.

The private sector costs are only summarized for homes that fall under the jurisdiction of a code, and are built to code levels. This means that homes that may fall under the Jurisdiction of a code but are not built to code levels only accrue costs for the portion of the home that was built to code levels. This is accomplished by multiplying the cost to comply by the Code

Adoption and Code Compliance Indices

Private sector costs varied by code type. **Table 260.5** identifies costs used to derive private sector costs.

Updated Benefits Estimates

During the development of the *FY 1997 Congressional Budget Request*, electricity energy savings, reported as primary or source energy, were thought to be site energy, and were multiplied by 3.019 to convert them to primary energy. When this mistake is corrected, the benefits estimates are:

	1997	2000	2010	2020
Total Primary Energy Displaced (TBtu/yr)	27	114	482	953
Total Energy Cost Savings (Millions $1995)	175	757	3,607	7,778
Carbon Equiv. Emissions Reductions (MMtons)	0.52	4.71	9.37	18.77

[Note: Tables 260.1-5 referred in the answer to Q260a are attached following the answer to Q260b.]

Q260b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A260b. It is impossible to say that the predicted benefits would never be achieved in the absence of Department of Energy funding. Rather, the benefits would most likely occur in most states from 10 to 15 years later due to the lack of Department support for building standards and guidelines. In 1991, forty States and territories had either no residential energy code or a code that dated back to 1975 or 1980. Only four States had updated their codes to 1986 efficiency levels. Of the remaining 12 States which had updated their residential energy codes to 1989 levels, all had done so using materials that were a product of the Department's energy code development process in cooperation with the building industry consensus code process and based on the Department's research or based on State Energy Conservation Program funding.

Similarly, in 1990, forty-six States had either no commercial code or a code that dated back to 1975 or 1980. Only four States had updated their codes to 1989 efficiencies. All had done so using materials that were a product of the Department's energy code development process in cooperation with the building industry consensus code process and based on the Department's research or based on State Energy Conservation Program funding.

APPENDIX TABLES FOR QUESTION 260.a

Table 260.1. Current Programs

Program Area	Sector	Energy Policy Act, 1992	Climate Change Action Plan (EPSE)
Increased Stringency (Voluntary Codes)	New residential buildings	Voluntary code development	Develop core materials
	New commercial buildings	Voluntary code development	Develop core materials
Adoption and Enforcement (State Code Upgrades)	New residential buildings	Voluntary	Support state adoption and enforcement
	New commercial buildings	Mandatory	Support state adoption and enforcement

Table 260.2. Reference Standards by Year

Reference Year	Residential	Commercial
1995	CABO MEC 1993	ASHRAE/IES 90.1-1989
2000	CABO MEC 1995	ASHRAE/IES 90.1-1989
2005	CABO MEC 1995 w/ 1994 DOE proposed changes	ASHRAE/IES 90.1-1998 (Tier 1)
2010	CABO MEC 1995 w/ 1994 DOE proposed changes	ASHRAE/IES 90.1-1998 (Tier 1)
2020	10% Improvement over CABO MEC 2010	ASHRAE/IES 90.1-1998 (Tier 2)
2030	10% Improvement over CABO MEC 2020	10% Improvement over ASHRAE/IES 90.1-1998 (Tier 2)

Table 260.3. Assumptions for Determining the Effects of Supporting Voluntary Codes

Current Policy	Year			
	Sector	**1995**	**2010**	**2020**
State Adoption (% of buildings)	Residential	28%	45%	45%
	Commercial	23%	40%	40%
Technology Performance (% of gross potential)	Residential	100%	100%	100%
	Commercial	100%	100%	100%
Code Compliance (% of net potential)	Residential	25%	25%	25%
	Commercial	25%	30%	30%

Table 260.4. Assumptions for Determining the Effects of Supporting Voluntary Code Upgrades

Current Policy	Year			
	Sector	1995	2010	2020
State Adoption (% of buildings)	Residential	60%	80%	60%
	Commercial	40%	70%	70%
Technology Performance (% of gross potential)	Residential	100%	100%	100%
	Commercial	100%	100%	100%
Code Compliance (% of net potential)	Residential	25%	62%	62%
	Commercial	25%	65%	65%

Table 260.5. Cost Assumptions by Code Type

Reference Year	Residential	Cost (per household)	Commercial	Cost (cost factor applied to savings)
1995	CABO MEC 1993	$845	ASHRAE/IES 90.1-1989	6.8
2000	CABO MEC 1995	$845	ASHRAE/IES 90.1-1989	6.8
2005	CABO MEC 1995 w/ 1994 DOE proposed changes	$942	ASHRAE/IES 90.1-1998 (Tier 1)	6.8
2010	CABO MEC 1995 w/ 1994 DOE proposed changes	$942	ASHRAE/IES 90.1-1998 (Tier 1)	6.8
2020	10% Improvement over CABO MEC 2010	$1,150	ASHRAE/IES 90.1-1998 (Tier 2)	11.4
2030	10% Improvement over CABO MEC 2020	$1,258	10% Improvement over ASHRAE/IES 90.1-1998 (Tier 2)	11.4

Q261. Please provide a listing of the recipients of (i) the $10,931,000 in funding in FY 1995, (ii) the $8,920,000 in FY 1996 funding, and (iii) the requested level of $15,850,000 in FY 1997 for Building Standards and Guidelines for each of Update State Codes, Voluntary and Federal Energy Codes, Loan/Loan Guarantee Standards, and Home Energy Rating Systems.

Q262. For each recipient of Building Standards and Guidelines funds identified in the response to question 261 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A261 and A262. The recipients of the funding for Building Standards and Guidelines in FY 1995 through FY 1997 are shown in the table below, as well as cost-sharing provided by each recipient for FY 1995 - FY 1997. Awards for FY 1996 have not yet been made, and recipients for FY 1997 funding will not be determined until 1997. Cost-sharing is expected to increase in FY 1996 and FY 1997 from that in FY 1995.

Building Standards and Guidelines Recipients and Cost-Share
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Alaska	135	TBD*	TBD	N
2	American Samoa	82	TBD	TBD	Y
3	Arkansas	43	TBD	TBD	N
4	California	579	TBD	TBD	Y/N
5	Colorado	2,954	TBD	TBD	Y/N
6	Georgia	7	TBD	TBD	Y
7	Guam	0	TBD	TBD	Y
8	Hawaii	53	TBD	TBD	Y
9	Idaho	40	TBD	TBD	Y
10	Indiana	50	TBD	TBD	Y
11	Iowa	95	TBD	TBD	Y
12	Kentucky	25	TBD	TBD	Y
13	Massachusetts	77	TBD	TBD	Y
14	Michigan	27	TBD	TBD	Y
15	Minnesota	476	TBD	TBD	Y
16	Mississippi	19	TBD	TBD	Y/N
17	Nevada	25	TBD	TBD	Y
18	New Jersey	36	TBD	TBD	Y
19	New Mexico	33	TBD	TBD	Y
20	North Dakota	10	TBD	TBD	Y
21	Northern Mariana Islands	0	TBD	TBD	Y
22	Ohio	95	TBD	TBD	Y
23	Oregon	211	TBD	TBD	Y
24	National Renewable Energy Laboratory	0	TBD	TBD	N
25	Pacific Northwest National Laboratory	0	TBD	TBD	N
26	Puerto Rico	0	TBD	TBD	Y
27	Rhode Island	74	TBD	TBD	Y
28	South Carolina	534	TBD	TBD	Y
29	South Dakota	72	TBD	TBD	Y

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
30	Texas	26	TBD	TBD	Y
31	Tennessee	22	TBD	TBD	Y
32	Utah	26	TBD	TBD	Y
33	Virginia	100	TBD	TBD	N
34	Vermont	110	TBD	TBD	Y/N
35	Washington	64	TBD	TBD	Y
36	West Virginia	15	TBD	TBD	Y
37	Wisconsin	156	TBD	TBD	Y
38	Virgin Islands	0	TBD	TBD	Y
39	States TBD	0	TBD	TBD	Y
	Total	6,271	**TBD**	**TBD**	

*To be determined.

Q263. For those Building Standards and Guidelines funding recipients identified in the response to question 261 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A263. Non-competitive grants were awarded in 1996 to those pilot states designated by the Department of Housing and Urban Development and the Federal National Mortgage Association as pilot states to test energy efficiency mortgages, in a coordinated effort to test the deployment of home energy rating systems on which those mortgages could be based. In FY 1996 those pilots will continue, as directed by Congress appropriations language. In addition, Mississippi will be added, at Congressional direction. The National Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

Q264. Page 402 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Lighting and Appliance Standards "[a]t the proposed funding levels":

	1997	2000	2010	2020
Total Primary Energy Displaced (TBtu/yr)	0	170	1,396	2,043
Total Energy Cost Savings (Millions $1995)	0	1,200	10,981	17,523
Carbon Equiv. Emissions Reductions (MMtons)	0	3.61	29.01	42.42

Q264a. Please provide detailed documentation of each of these claimed benefits.

A264a. The energy savings, cost savings, and carbon emissions estimates listed above were developed as part of the Quality Metrics process in support of the FY 1997 budget request. Energy savings estimates were developed using the LBNL Residential Energy Model, supported by the extensive Technical Support Documents and analyses conducted as part of the standards development process. Energy cost savings were calculated as a direct function of energy savings using energy prices from the Energy Information Administration's *1995 Annual Energy Outlook*, and carbon reductions were calculated in similar fashion using conversion factors developed by EERE's Office of Planning and Assessment.

The estimates assume that new standards for the following appliances and equipment become effective in 1998: refrigerators and freezers, room air conditioners, mobile home furnaces, direct heating equipment, gas and oil water heaters, kitchen ranges and ovens (not including microwave ovens), clothes washers, dishwashers, central air conditioners, central heat pumps, fluorescent lamp ballasts, and pool heaters. These benefit estimates also include savings from testing and labeling of incandescent lamps, luminaires, personal computers, printers, and copiers as provided for in the Energy Policy Act of 1992.

Energy savings were estimated in similar fashion for each of the above classes of appliances and equipment. An example of the approach used is detailed in the table on the follows.

Central Air Conditioners

Year	Baseline Target Market Energy Use (Quads Source)	Baseline Target Market Energy Use (Millions)	Number of Units Installed (Millions)	Unit Efficiency (SEER)	Electricity Displaced (Quads Source)
1997	1.00	37.4	3.1	11	0.00
2000	1.03	39.6	3.2	15	0.02
2005	1.09	43.0	3.1	15	0.13
2010	1.18	46.8	3.6	15	0.24
2015	1.27	50.1	3.8	15	0.33
2020	1.37	53.3	3.9	15	0.36

The column **Baseline Target Market Energy Use** indicates forecast annual energy use for this class of equipment in the absence of stricter standards; **Baseline Target Market Total Units** indicates the projected population of central air conditioners over time. Both are provided for perspective. **Number of Units Installed** is the annual number of units affected by the new standards–it is assumed that the new standards come into effect in 1998, and that all units after this date are subject to the standards (i.e., 100 percent penetration/coverage). **Unit Efficiency (SEER–Seasonal Energy Efficiency Ratio)** is a measure of the relative average efficiencies before (11) and after (15) the new standard. **Electricity Displaced** is the cumulative annual effect of the standard, computed by the LBNL Residential Energy Model, accounting for all units affected by the standard and including the impacts of different climate zones on annual usage (and savings).

Similar savings were calculated for each of the classes of appliances and equipment listed on the previous page, and the total of these estimates is the value given in the Budget Request.

Q264b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A264b. DOE has a unique legislated role in establishing national energy efficiency standards for appliances and equipment. DOE conducts the analyses necessary to determine the technically achievable and economically justified standards levels as provided by law, builds consensus among manufacturers, trade associations, public interest groups, and other interested parties, issues notices of proposed rulemakings, holds public hearings, and issues final rules. DOE also establishes testing procedures. Performing these functions at the Federal level avoids the inefficiencies associated with having a multiplicity of standards established by other levels of government (e.g., the States).

Q265. Please provide a listing of the recipients of (i) the $10,328,000 in funding in FY 1995, (ii) the $5,311,000 in FY 1996 funding, and (iii) the requested level of $8,000,000 in FY 1997 for Lighting and Appliance Standards for each of Residential Appliances: Test Procedures, Commercial Appliances: Test Procedures, Certification and Compliance, and EPACT NFRC Research Plan.

Q266. For each recipient of Lighting and Appliance Standards funds identified in the response to question 265 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A265 and A266. Funding recipients for FY 1995-FY 1997 are shown in the following table. Because the Lighting and Appliance Standards Program is a regulatory, and not a research and development program, the recipients did not directly provide any cost-sharing funds.

Lighting and Appliance Standards Recipients and Cost-Share
(In Thousands of $)

		Cost-Share			
No.	Major Recipient	FY 1995	FY 1996	FY 1997	Competitive
	RESIDENTIAL APPLIANCE				
1	National Institute of Standards and Technology	0	0	0	N
2	Lawrence Berkeley National Laboratory	0	0	0	N
3	National Renewable Energy Laboratory	0	0	0	N
	COMMERCIAL APPLIANCE				
4	National Institute of Standards and Technology	0	0	0	N
5	Lawrence Berkeley National Laboratory	0	0	0	N
6	National Renewable Energy Laboratory	0	0	0	N
7	Oak Ridge National Laboratory	0	0	0	N
8	Pacific Northwest National Laboratory	0	0	0	N
	CERTIFICATION & COMPLIANCE				
9	National Institute of Standards and Technology	0	N/A	N/A	N
	EPACT NFRC RESEARCH PLAN				
10	National Fenestration Research Council (NFRC)	0	N/A	N/A	N
	Total	**0**	**0**	**0**	

Q267. For those Lighting and Appliance Standards funding recipients identified in the response to question 265 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A267. Two recipients, the National Institute of Standards and Technology (NIST) and the National Fenestration Rating Council (NFRC), were awarded funds on a noncompetitive basis because they were cited in the authorizing legislation. The Energy Policy and Conservation Act, as amended, authorized the Secretary of Energy to direct the National Bureau of Standards (currently called NIST) to assist in developing new or amended test procedures (Section 323(b)(C)). The Energy Policy Act, section 121(a) directed the Secretary to provide financial assistance to support a voluntary national window rating program that will develop energy ratings and levels for windows and window systems. Section 121(a)(3) states that "such rating system shall be developed by the National Fenestration Rating Council according to commonly accepted procedures for the development of national testing procedures and labeling programs."

The National Laboratories were also awarded funds on a non-competitive basis. Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurement for the management of each laboratory.

Management and Planning

Q268. Please provide a listing of the recipients of (i) the $8,595,000 in funding in FY 1995, (ii) the $5,450,000 in FY 1996 funding, and (iii) the requested level of $13,335,000 in FY 1997 for Evaluation and Planning.

Q269. For each recipient of Evaluation and Planning funds identified in the response to question 268 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A268 and A269. Funding recipients for FY 1995-FY 1997 are shown in the following table. Since the funds are used for planning and evaluation, there is no cost-sharing.

Evaluation and Planning Recipients and Cost-Share
(In Thousands of $)

		Cost-Share			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Pacific Northwest National Laboratory	N/A	N/A	N/A	N
2	Lawrence Berkeley National Laboratory	N/A	N/A	N/A	N
3	Brookhaven National Laboratory	N/A	N/A	N/A	N
4	D&M Contacting Inc.	0	0	0	N
5	EASI	0	0	0	N
6	CAMBER	0	0	0	N
7	Department of Commerce	0	0	0	N
8	Dyncorp	0	N/A	N/A	Y
	Total	**0**	**0**	**0**	

Q270. For those Evaluation and Planning funding recipients identified in the response to question 268 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A270. Laboratory funding is based on a determination by DOE project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by M&O contracts awarded through competitive procurements for the management of each Laboratory. Consistent with the Department's desire to support small businesses, noncompetitive awards were made to three 8(a) businesses that could provide the required evaluation and planning support.

Federal Energy Management Program

Q271. Page 430 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the Federal Energy Management Program:

	2000	2010	2020
Total Primary Energy Displaced (Quads)	**0.05**	**0.16**	**0.26**
Total Cost Savings in Year (1995 $-Billions)	**.348**	**1.185**	**2.146**
Carbon Equivalent Savings (MMTCE)	**1.09**	**3.29**	**5.44**

Q271a. Please provide detailed documentation of these claimed benefits.

A271a. The benefits projected for the Federal Energy Management Program (FEMP) are grounded in fifteen years of Federal energy management experience, which has accumulated $9.8 billion (1994 constant dollars) in agency-reported Federal energy bill reductions from FY 1985 through FY 1994. The projections are predicated on meeting Federal energy management goals established by law and Executive Order in FY 2000 and FY 2005, and continuing savings improvements through 2020. Assumptions underlying the projections are:

- Savings estimates are for Federal building energy efficiency improvements from capital energy project investments only. Mobility, process and production savings are not part of the estimate, although anticipated. Consequently, these numbers are very conservative and underestimate savings benefits.

- Savings attributable to operations and maintenance actions and new building design review are not included.

- Savings from increased purchasing of cost-effective, high-efficiency products and services are not included in projections.

- Savings estimates do not include those attributable to DOE's In House Energy Management program.

- Based on historical experience of DOE's In House Energy Management program as a model, an average project is assumed to have a 4-year payback, 20-year life, and a total return of $5 for every $1 invested, saving 14,000 Btu per year per $1 invested. Savings estimates exclude savings that will accrue from investments in place prior to FY 1997, resulting in under estimate of FEMP annual impacts by $900 million in FY 2000, $600 million in FY 2005, and $300 million in FY 2010.

- Gross square feet of Federal building space held constant at 1994 levels.

- Inflation rates, carbon content coefficients, energy prices are same as used across the Office of Energy Efficiency and Renewable Energy for Quality Metrics calculations. Site energy savings estimates that represented meeting FY 2000 and FY 2005 goals, along with historical fuel mix patterns were provided as inputs for Quality Metrics calculations; these were converted to primary energy savings using standard Quality Metrics methodologies, with subsequent application of standard energy price assumptions and carbon coefficients to project cost savings and carbon savings.

- Quality Metrics peer review: EERE contracted with Arthur D. Little (ADL) to design and implement an external peer review process of these estimates. ADL examines technology assumptions and resulting market penetration of EERE technologies. Most of the high impact and high uncertainty programs have been reviewed, and ADL is currently completing the review of the remaining technologies and programs.

Q271b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A271b. The Federal Energy Management Program leads the Federal Government effort to achieve energy savings goals established by law and Executive Order through an integrated program focused on its customer needs. In recognition of the importance of Federal energy management, the Department has relocated FEMP into the Office of the Assistant Secretary for Energy Efficiency and Renewable Energy. That increases its visibility and access to all energy efficiency and renewable energy programs.

Through the Interagency Energy Policy Committee, FEMP establishes overarching energy management policies and priorities in collaboration with the major Federal agencies. The implementation of these policies and priorities is coordinated through the Interagency Energy Management Task Force, which is composed of the top level energy managers for the major agencies. FEMP enables and facilitates the agencies in achieving increased energy efficiency through: developing guidance and conducting awareness and recognition activities; providing technical training, tools, assistance, and information; developing and implementing innovative private sector (energy service company, utility) financing mechanisms; informing private sector entities about Federal business practices; encouraging Federal-private and Federal-State partnerships that expand resources available to agencies; and working to identify and overcome barriers to sound energy management practices. Regionally-focused technical assistance is being provided through the six Energy Efficiency and Renewable Energy Regional Support Offices and States in order to ensure timely and appropriate assistance and the best possible use of local resources (State programs, knowledge of local building codes, etc.). FEMP receives and consolidates annual reports of agency energy costs, efficiency investments and accomplishments, and reports progress against established Government-wide goals to Congress on an annual basis.

Current reporting indicates the effectiveness of this interagency energy management approach. In FY 1994, agencies reported a decrease of 11.2% in energy use per gross square foot of building space, which exceeded the 1995 goal of 10% reduction from a 1985 baseline. Energy costs (1994 constant dollars) in FY 1994 were reduced by $1.5 billion from FY 1985 levels, with cumulative cost savings of $9.8 billion over the period.

The above is stated to illustrate the role of FEMP in creating the Federal capacity to identify, assess, fund, and manage the significant potential energy and water efficiency potentials in Federal facilities. FEMP plays a critical role in identifying and working with agencies to overcome institutional, financial, and information barriers to achieving energy and water management goals established by law and Executive Order. The Federal rules, promulgated under FEMP auspices, for the governance of energy management in Federal facilities have proven to be effective in saving energy and reducing energy costs. FEMP, working with the Federal agencies, has provided the required technical information, tools, training and assistance necessary to the proper and effective implementation of the Federal energy management mandate. Further, FEMP has emerged as a key facilitator of Federal-private and Federal-State partnerships that serve multiple sites and multiple agencies, and expand funding and services available to agencies.

Accomplishing the FY 1995 ten percent goal required an average annual reduction of 1% in energy consumption per gross square foot. This was accomplished mainly through the investment of approximately $3.3 billion (1994 constant dollars) in appropriations over the period FY 1980 through FY 1994. Energy management goals of a 20% reduction in FY 2000 and 30% reduction in FY 2005 (in energy consumed per gross square foot from the 1985 baseline), require the Federal Government to *double* the annual rate of efficiency improvements to 2%. This implies a doubling of investment as well–an estimated $6.3 billion investment required FY 1995 through FY 2004.

With Federal appropriations for energy efficiency projects declining (down $166 million in FY 1996 from FY 1995 in DOD, DOE and GSA alone), a massive shift to Energy Savings Performance Contracting (ESPC) utilizing private financing, is required. FEMP plays a critical role in creating the ESPC vehicles necessary for the infusion of private capital into Federal facilities. FEMP will establish with FY 1997 funding six FEMP Energy Saver Delivery Contracts utilizing *indefinite quantity, indefinite delivery* provisions of the Federal Acquisition Regulations that are expected to generate up to $250 million each in private sector funding over ten years. It is anticipated that, properly facilitated by FEMP field staff, these contracting vehicles will serve multiple agencies at multiple sites in a manner that reduces paperwork and speeds completion of projects. Further, individual ESPCs will be established for specific sites as required by individual circumstances, and utility financing of projects will be developed as well. Additional ESPC vehicles and utility financing will need to be developed and implemented in future fiscal years. *Without the FEMP ESPC*, attainment of an estimated $15 billion net energy cost savings (i.e., deficit reduction) would be put in jeopardy.

Q272. Please provide a listing of the recipients of the $2,886,000 in funding in FY 1995 for the Federal Energy Efficiency Fund.

Q273. For each recipient of Federal Energy Efficiency Fund funds identified in the response to question 272 above, please provide the level of funding provided by that recipient as cost-sharing for FY 1995.

A27a & A273. The following information is provided for the Federal Energy Efficiency Fund for FY 1995.

Federal Energy Efficiency Fund Recipients and Cost-Share
(In Thousands of $)

No.	Major Recipient	Cost-Share FY 1995	Competitive
1	National Oceanic & Atmospheric Administration, National Marine Fisheries Service, Seattle, WA	390	Y
2	National Park Service, White House, Washington, DC	35	Y
3	National Park Service, Yosemite National Park, Yosemite, CA	23	Y
4	National Park Service, Channel Islands National Park, Oxnard, CA	90	Y
5	U.S. Coast Guard, Honolulu, HI	60	Y
6	U.S. Coast Guard, Curtis Bay, MD	49	Y
7	Goddard Space Flight Center, Greenbelt, MD	55	Y
8	Kennedy Space Center, Cape Canaveral, FL	461	Y
9	Museum Support Center, Suitland, MD	90	Y
10	Forest Service, Shasta-Trinity National Forest, Redding, CA	3	Y
11	Forest Service, Kaibab National Forest, Williams, AZ	5	Y
	Total	1,261	

Q274. For those Federal Energy Efficiency Fund funding recipients identified in the response to question 272 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A274. All Federal Energy Efficiency Fund proposals were competitively evaluated and selected in accordance with the guidelines issued by the Department of Energy in response to the requirements of Section 546(b)(3) of the Energy Policy Act of 1992.

Q275. Please provide a listing of the recipients of (i) the $2,678,000 in funding in FY 1995, (ii) the $3,084,000 in FY 1996 funding, and (iii) the requested level of $12,700,000 in FY 1997 for Project Financing.

A275. The following table identifies FY 1995 and FY 1996 DOE funding for Project Financing. FY 1997 funding is in the planning stage.

Project Financing Funding Recipients and Cost-Share
(In Thousands of $)

		DOE Funding			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Enterprise Advisory Services, Inc.	92			Y
2	State Initiative		200	TBD	N
3	Department of Army, Huntsville	75			
4	Lawrence Berkeley National Laboratory	290	390	TBD	Y
5	National Renewable Energy Laboratory	1,739	1,795	TBD	Y
6	Pacific Northwest National Laboratory	250	495	TBD	Y
7	Printing	31			
8	Sandia National Laboratories	55			
9	Seattle Regional Support Office	55	15	TBD	N
10	CDSI	17	22	TBD	Y
11	Camber Corp.	60			
12	Energy Technology Engineering Center		30		Y
13	Denver Regional Support Office		25	TBD	N
14	Boston Regional Support Office		9	TBD	N
15	Seattle Regional Support Office		15	TBD	N
16	Small Business Innovative Research Program	14	30		
17	Chicago Regional Support Office		59	TBD	Y
	Total	**2,678**	**3,085**		

Q276. For each recipient of Project Financing funds identified in the response to question 275 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A276. There are no cost-shared funds for Project Financing.

Q277. Please provide a listing of the recipients of (i) the $7,953,000 in funding in FY 1995, (ii) the $8,329,000 in FY 1996 funding, and (iii) the requested level of $9,200,000 in FY 1997 for Technical Guidance and Assistance.

A277. The following table identifies FY 1995 and FY 1996 DOE funding for Technical Guidance and Assistance. FY 1997 funding is in the planning stage.

Technical Guidance and Assistance Funding Recipients and Cost-Share
(In Thousands of $)

		DOE Funding			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Albuquerque Operations Office		33		N
2	Atlanta Regional Support Office	5	26	TBD	N
3	Boston Regional Support Office	20	28	TBD	N
4	Camber Corporation	60	0		N
5	Chicago Regional Support Office	20	59	TBD	Y
6	Dallas Regional Support Office	20			N
7	Denver Regional Support Office	20	35	TBD	N
8	Dyncorp		30		N
9	Enterprises Advisory Services, Inc.	80			N
10	Kansas City Regional Support Office	15			N
11	Golden Field Office	800	1,146		Y

No.	Major Recipient	DOE Funding FY 1995	FY 1996	FY 1997	Competitive
12	New York Regional Support Office	125	20	TBD	N
13	CDSI	50	107	TBD	Y
14	Small Business Innovative Research		155	TBD	Y
15	Department of the Army		186		N
16	State Initiative		200		N
17	Demonstration Project	40			N
18	Greening Support		1		
19	Los Alamos National Laboratory	5			Y
20	Sandia National Laboratories	60	75	TBD	Y
21	Argonne National Laboratory	5			
22	Brookhaven National Laboratory	5			
23	Idaho National Engineering Laboratory	5			
24	Lawrence Berkeley National Laboratory	890	1,160	TBD	Y
25	Lawrence Livermore National Laboratory	5			
26	Oak Ridge National Laboratory	150	145	TBD	Y
27	Energy Technology Engineering Laboratory	5			
28	National Renewable Energy Laboratory	3,187	2,903	TBD	Y
29	National Institutes of Science and Technology	229	235	TBD	N
30	Oak Ridge Institute for Science and Education		110		Y
31	Pacific Northwest National Laboratory	1,965	1,190	TBD	Y
32	Philadelphia Regional Support Office	30	5		
33	San Francisco Regional Support Office	32			N
34	Seattle Regional Support Office	125	100	TBD	N
35	Printing		2		
36	Headquarters Procurement	0	375		N
	Total	7,953	8,326	TBD	

Q278. For each recipient of Technical Guidance and Assistance funds identified in the response to question 277 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A278. CRADAs are funded by the Federal Energy Management Program's New Technology Demonstrations featuring cutting-edge, energy efficient technologies. All of the CRADAs are cost-shared and information is provided as follows:

There are three CRADAs with the Pacific Northwest National Laboratory that have been signed and will be completed in FY 1996.

1. Demonstration of natural gas engine driven air conditioning systems at Willow Grove Naval Air Station (NAS), Willow Grove, Pennsylvania. This was two demonstrations, but one CRADA. The CRADA was signed in July 1993 and will be completed in FY 1996.

Total Contributions:	$377,424
PNNL/DOE Contributions:	$229,979
NAS Willow Grove:	$58,850
Utility:	$88,595

2. Demonstration of natural gas engine drive heat pump at Fort Sam Houston, Texas. The CRADA was signed February 1994 and will be completed in FY 1996.

Total Contributions:	$389,923
PNNL/DOE Contributions:	$169,923
Fort Sam Houston:	11,000
Manufacturer:	$209,000

3. Demonstration of residential water heat conversion from electric to natural gas. CRADA was signed in 1994 and will be completed in FY 1996.

Total Contributions:	$86,615
PNNL/DOE Contributions:	$60,250
Fort Stewart:	$2,400
Huntsville Corps of Engineers:	$7,500
Manufacturer:	$16,465

There are four CRADAs underway, two demonstrations awarded by PNNL, one by NREL and one by ORNL.

1. Demonstration of full spectrum polarized lighting.

		FY 1995	FY 1996	FY 1997
Total Contributions:	$101,600	$25,000	$76,600	-------
PNNL/DOE Contributions:	$53,600			
Department of Defense:	$5,600			
Manufacturer:	$42,400			

2. Demonstration of polarized lighting panels.

		FY 1995	FY 1996	FY 1997
Total Contributions:	$60,200	$16,000	$44,200	-------
PNNL/DOE Contributions:	$40,000			
Department of Defense:	$5,600			
Manufacturer:	$14,600			

3. Demonstration of a desiccant cooling technology.

		FY 1995	FY 1996	FY 1997
Total Contributions:	$157,000	$25,000	$66,000	$66,000
NREL/DOE Contributions:	$67,000			
U.S. Army CERL Contribution:	$90,000			

4. Demonstration of Radiant Control Roofing Technologies.

		FY 1995	FY 1996	FY 1997
Total Contributions:	$100,625	$50,628	$33,713	$16,284
ORNL/DOE Contributions:		$44,128	$32,713	$16,284
Thermal Shield:		$6,500	$1,000	$0

Q279. For those Technical Guidance and Assistance funding recipients identified in the response to question 277 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A279. Funds awarded on a non-competitive basis are reflected in the table that responds to question 278 above. National Laboratory funding is based on a determination by Departmental project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

Q280. Please provide a listing of the recipients of (i) the $3,649,000 in funding in FY 1995, (ii) the $5,334,000 in FY 1996 funding, and (iii) the requested level of $6,800,000 in FY 1997 for Planning, Reporting, and Evaluation.

A280. The requested information is provided in the following table.

Planning, Reporting, and Evaluation Funding Recipients and Cost-Share
(In Thousands of $)

		DOE Funding			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
1	Advanced Sciences, Inc.	79	0		N
2	Atlanta Regional Support Office	6	14	TBD	N
3	Boston Regional Support Office	20	88	TBD	N
4	Chicago Regional Support Office	92	20	TBD	N
5	Dallas Regional Support Office	20	10	TBD	N
6	Dyncorp	50	0		N
7	Enterprises Advisory Services, Inc.	730	634		N
8	E Source	8	16		N
9	Solar Energy Industries Association	180	200		N
10	Awards Brochure	25	0	TBD	Y
11	George Mason University	15	0		N
12	Quality Leadership Council	8	20		N
13	CDSI	55	36	TBD	Y
14	Small Business Innovative Research	37	75	TBD	Y
15	Earth Day Activities	5	30		N
16	Exhibit in Austin, Texas	0	1		N
17	Printing	60	10	TBD	N
18	Energy Award Winners	82	86	TBD	Y
19	Awards Invitations	0	25		Y
20	Awards Luncheon	14	30	TBD	Y
21	PERI	42	0		Y

		DOE Funding			
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**	**Competitive**
22	Plaques for Energy Award Winners	20	22	TBD	N
23	Pacific Northwest National Laboratory	248	605	TBD	Y
24	Lawrence Berkeley National Laboratory	250	190	TBD	Y
25	McNeil Technologies, Inc.	1	186	TBD	N
26	National Renewable Energy Laboratory	1,225	2,042	TBD	Y
27	New York Regional Support Office	88	20	TBD	N
28	Oak Ridge National Laboratory	15	592	TBD	Y
29	Philadelphia Regional Support Office	20	35	TBD	N
30	SEMA	49	0		N
31	San Francisco Regional Support Office	20	0	TBD	N
32	Sandia National Laboratories	25	55		Y
33	Seattle Regional Support Office	120	20	TBD	N
34	U.S. Department of Agriculture	39	0		N
35	Assoc. Energy Engineers	0	5		N
36	Alliance to Save Energy	0	100		N
37	Small Business Technology Transfer	0	8		N
38	State Initiative	0	100	TBD	Y
39	Award Poster	0	16	TBD	N
40	Mailings	0	3		N
41	ADP/Software	1	40	TBD	Y
	Total	**3,649**	**5,334**	**TBD**	

Q281. **For each recipient of Planning, Reporting, and Evaluation funds identified in the response to question 280 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.**

A281. There are no cost-shared funds for Planning, Reporting, and Evaluation.

Q282. **For those Planning, Reporting, and Evaluation funding recipients identified in the response to question 280 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.**

A282. Funds awarded on a non-competitive basis are reflected in the table that responds to question 278 above. National Laboratory funding is based on a determination by Departmental project managers that Laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the Laboratories is set by the M&O contracts awarded through competitive procurements for the management of each Laboratory.

Industry Sector Program Mission

Q283. **On page 452 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Analysis [sic] of OIT programs indicate that if successful OIT developed technologies could lead to reductions of 2.0 to 5.5 quads in industrial energy demand by the year 2010 (depending on the speed of market penetration of new technologies). This would result in annual energy cost savings of up to $19 billion, and annual carbon reductions up to 106 million metric tons."**

Q283a. Please provide detailed documentation of each of these claims, including the peer review process undertaken.

A283a. The Office of Industrial Technologies R&D program crosses several major industries encompassing literally hundreds of different technology areas. To develop estimates of the estimated energy savings of the overall OIT R&D portfolio and cost and carbon emissions savings associated with these energy efficiency improvements, a formal analysis of the energy savings potential was conducted on a project-by-project basis for over 125 medium- to high-risk R&D projects. Benefits from these individual projects were then aggregated to build up the OIT-wide estimated energy savings and carbon emissions benefits.

To estimate energy savings, each OIT-supported technology was compared to a "competing" technology; i.e., the technology (or process) that is trying to be improved on. The specific market niche of each technology, its size (in terms of energy use), growth rate, and estimated market penetration were estimated. The expected market growth of the technology was bounded by the Energy Information Administration's energy use projections for specific industries.

For each technology, estimates of the capital cost, non-energy cost, energy use, and waste and emissions characteristics were made for both the OIT-supported technology and the "competing" technology. This data was entered into a technology diffusion model which in turn generated an expected Internal Rate of Return for the OIT technology. The magnitude of the IRR (based predominantly on the expected cost differences between the OIT and "competing" technologies) then dictated the rate at which the OIT technology is expected to diffuse into the market, and the ensuing energy, carbon and other savings that will accompany that rate of market penetration. To estimate the benefits of the full OIT portfolio, the energy and carbon emissions savings of individual technologies and "planning units" were simply aggregated.

OIT's benefit estimation process is still a fairly new one and it continues to be improved in an incremental basis. Expert outside reviewers from the Arthur D. Little consulting firm have peer reviewed (and continue to review) the assumptions, market penetration estimates, benefit estimates, model runs and other aspects of the metrics process for each of our 125-odd technologies on which the estimates of the full portfolio that appeared in the FY97 budget document were based. A.D. Little's experts have met with individual OIT program managers and questioned the assumptions and underlying data for our benefit estimates. As a result of A.D. Little's reviews, some revisions have been made while other data have been validated by the process.

While the total magnitude of the potential benefits of the OIT portfolio may seem aggressively optimistic to some, the absolute size of the energy, environmental and other savings of the portfolio-wide projections may not be as important as the relative differences among individual R&D projects. Such information on individual projects and planning units can be highly useful to the organization as it develops its overall R&D strategy with an eye toward maximizing the national benefit from the investment of public funds.

Q283b. Please detail the funding provided by either DOE directly or indirectly through its contractors to produce these analyses.

A283b. DOE has provided $150,000 to develop and implement the methodology. This methodology is expected to be useful over multiple fiscal years and is believed to be a small but prudent investment which would likely be returned in full to OIT (and the public) if the data generated in the process were to be instrumental in helping to terminate early just one R&D project with unfavorable expectations.

Q283c. Please document why these benefits would not occur in the absence of DOE funding.

A283c. In the absence of DOE funding, the research and development projects co-funded by the Office of Industrial Technology (OIT) would be delayed or deferred by private industry. OIT projects are high-risk endeavors that advance novel process or product technologies through critical applied R&D phases historically underfunded by private industry. The Department's involvement in co-funding these projects with industry serves to accelerate the development and introduction of important technological innovations vital to U.S. industry's ability to become more energy efficient through market-driven investments.

Current trends indicate that corporate R&D expenditures are being refocused to even shorter-term, quicker-payback projects, related to near-term business goals, in response to corporate restructuring and financial market pressures. According to *Energy R&D: Shaping Our Nation's Future in a Competitive World*, by the Secretary of Energy Advisory Board Task Force on Strategic Energy Research and Development (chaired by Daniel Yergin), June 1995, the "long term" in corporate research is now only five years–and in some cases just three. As a result, longer-term, higher-risk, more uncertain projects are less likely to be undertaken in the private sector.

The experience of the last few years suggests that U.S. financial markets now penalize companies for a longer-term R&D commitment. The president of Lockheed Martin recently described what happened when he was president of Martin Marietta and told a group of Wall Street stock analysts that his company planned to spend more on R&D. "They ran out of the room," he said, "and the stock dropped 11 percent in two days." Mutual fund managers, anxious about their quarterly rankings against other mutual fund managers, are going to be much more interested in a firm's quarterly performance than in its commitment to develop higher-risk technologies with a five-year-plus time horizon. And one way for a company to improve quarterly performance is by not spending money whose effects will not be felt in the marketplace for half a decade.

Industries of the Future (Specific)

Q284. On page 461 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The estimated benefits from the FY 1997 project portfolio by 2010 include a cumulative energy reduction of 4 quadrillion Btu's, a reduction in NOx and SOx and CO2 emissions by 4,200 tons/year, 44,000 tons/year, and 256 million tons/year, and a 673 million tons per year reduction in solid waste production and waste avoidance."

Q284a. Please provide detailed documentation of each of these claimed benefits, including the peer review process undertaken.

A284a. The energy, economic and environmental benefits claimed for the Industries of the Future program derive from a three-step process, as follows:

Quality Metrics (QM) Sector Analysis: OIT conducts detailed, project-level analysis of the energy, economic, and environmental characteristics for each of the technology research and development projects it funds. Analysis is performed using a computer-based modeling tool called the OIT Project Benefit Analysis Worksheet that was developed specifically for this purpose. The modeling tool enables OIT to compare the predicted technical and market performance of new, energy-efficient technologies with the current state-of-the-art technology alternative by assessing their relative costs, energy use (by fuel type), waste reduction, and market performance. The model employs standard financial evaluation methodologies to compare alternate technology investments over the lifetime of the technology, including the internal rate of return for a technology investment.

Data required to compare technology investments is obtained from research performers, equipment users, industrial studies, government-collected data, and manufacturers. This data is reviewed by several DOE experts in the appropriate technology area to verify that the information is accurate and sound. The model calculates a project's expected energy and cost savings based on the fuels displaced/used (by type), fuel-specific energy costs, relative capital and operating costs, non-fuel production cost savings, equipment life, size of the market, the market penetration rate, and other project specific information. Energy costs savings are calculated based on the type and amount of fuel saved and the cost of that fuel for the industrial sector. Fuel costs are based on national surveys of fuel expenditures for each state as reported by the Energy Information Administration. Environmental benefits include the reduction in combustion-related emissions that are avoided by employing the more energy-efficient technology. They are calculated using the amount of fuel combustion avoided and their associated emissions loadings (SO_2, NO_x, CO_2, etc.). Energy, cost, and environmental benefits reported for a specific program represent the aggregated benefits of the individual projects included within that program.

QM Integrated Results: In addition to the rigorous sector analysis conducted, the Quality Metrics process uses an integrated model to perform an equilibrium analysis to estimate sector totals. By using an integrated model, interactions between programs within a sector can be accounted for (for example efficiency programs reducing electricity demand) and double counting can be eliminated.

Quality Metrics peer review: EERE contracted with Arthur D. Little (ADL) to design and implement an external peer review process of these estimates. ADL examines technology assumptions and the resulting market penetration of EERE technologies. Most of the high impact and high uncertainty programs have been reviewed, and ADL is currently completing the review of the remaining technologies.

Petroleum Refining: Table 1 contains a summary of the energy and environmental benefits calculated for the Petroleum Refining program using the first two models. Because of the uncertainties involved in calculating the numbers for the QM Sector Analysis (Table 1), the results from the QM Integrated Results process were used for the Congressional Budget Request statement noted above.

SUMMARY
QUALITY METRICS ASSESSMENT OF ENERGY AND ENVIRONMENTAL BENEFITS FOR THE REFINING INDUSTRY PROGRAM
Table 1

Project	Year 2000	Year 2010
Total Primary Energy Displaced, Quadrillion Btu	0.21	0.65
Primary Electricity Displaced, Quadrillion Btu	0.001	0.007
Primary Coal Displaced, Quadrillion Btu	0.001	0.005
Primary Gas Displaced, Quadrillion Btu	0.003	0.123
Primary Oil Displaced, Quadrillion Btu	0.207	0.521
Carbon Equivalent Emissions Reductions, MMTons	4.13	12.17
SO_x Reductions, MMTons	0.079	0.224
NO_x Reductions, MMTons	0.029	0.084
Particulates Displaced, MMTons	0.007	0.007
VOCs Displaced, MMTons	0.001	0.001
Other Wastes Displaced, 100 Thousand tons	96.2	73.4

Steel Industry: DOE-funded steel projects have the potential to reduce energy consumption by 0.1 quad/yr (see question #313). Coal is a predominant fuel in many of the steel process. Assuming coal produces 209.6 lbs of CO_2/mmBtu, 0.5 lb NO_x/mmBtu, and 0.12lbs SO_x/mmBtu, these energy savings therefore result in:

- 0.1 quads energy saved/yr
- 25,000 tons/yr NO_x
- 6,000 million tons/yr SO_x
- 10.48 million tons tons/yr CO_2

Metal Casting:
Year 2010

- Total Energy Displaced (Quadrillion Btu's)= 0.05
- NO_x = 0.003
- SO_x = 0.008
- CO_2 = 0.993

- Solid Waste = 0.225

Forest Products:

- 0.57 quads energy saved/yr
- 200 millions tons of waste reduced or avoided/year
- 60,444 tons/yr NO_x
- 156,219 tons/yr SO_x
- 15,396,327 tons/yr CO_2
- 189,182,300 tons/yr solid waste

Aluminum:

- 0.41 Quad in primary aluminum metal production (see 317a)
- 0.90 Quads in light weight vehicles (see 317b)
- 92 million tons of greenhouse emissions (see 317c)
- 0.8 million tons of salt cake land fill (see 298d)

Glass: These benefits encompass the targets identified by industry at the time the 1997 budget was developed. In the Glass Vision process, OIT asked industry what R&D areas would be a priority for them based on how they would want to look, as an industry, in 2020. In order to be a viable industry in the year 2020, they identified these targets as priorities for their industry. For example, an estimation of bringing all glass facilities 50% closer to ideal energy consumption from where they were in 1995 averages out to a minimum of 20%. Some companies are operating at 6-8 million Btus of energy to melt one ton of glass, where theoretical lies at 2.2 million Btus. In light of energy losses, an improvement to 3.5 million Btus is a probable ideal energy consumption. These targets have been more clearly defined in the Glass Industry Vision, which will be signed by representatives from the industry and the Secretary of Energy on April 29, 1996.

Chemicals: Table 2 contains a summary of the energy and environmental benefits calculated for the Chemical Industry using the Benefit Analysis Worksheets.

SUMMARY
QUALITY METRICS ASSESSMENT OF ENERGY AND ENVIRONMENTAL BENEFITS FOR THE CHEMICAL INDUSTRY PROGRAM
Table 2

Project	Year 2010
Total Energy Displaced, Quadrillion Btu	1.366
Electricity Displaced, Quadrillion Btu	0.034
Coal Displaced, Quadrillion Btu	(0.006)
Gas Displaced, Quadrillion Btu	0.583
Oil Displaced, Quadrillion Btu	0.755
Carbon Dioxide Emissions Reductions, Million Tons	82
SO_x Reductions, Thousand Tons	165
NO_x Reductions, Thousand Tons	102
Particulates Displaced, Thousand Tons	13
VOCs Displaced, Thousand Tons	2.68
Other Wastes Displaced, Thousand Tons	23,400

Q284b. Please document why these benefits would not occur in the absence of DOE funding.

A284b. The projects funded by the Petroleum Refining program were selected on the basis of competitive awards through an assessment process that is responsive to the public benefit. Industry acting alone typically will not pursue energy conservation R&D that carries high technical risk or requires large capital expenditures. Industry will also not perform R&D that responds to improving the public benefit (even though there could be some positive benefit to the industry itself). A variety of technologies with low pay-back potential fall into this category, such as alternative fuel utilization, industrial waste utilization, and materials recycling technology. Industry will not support R&D in collaboration with competitors that addresses areas that can be defined as "competitive." Industry alone usually will selectively avoid R&D with a long-term expected pay-back period. Corporate investment horizons today for industry R&D expenditures are extremely short.

Steel: The projects funded by the Steel program were selected on the basis of competitive awards through an assessment process that is responsive to the public benefit. Industry acting alone typically will not pursue energy conservation R&D that carries high technical risk or requires large capital expenditures. Industry will also not perform R&D that responds to improving the public benefit (even though there could be some positive benefit to the industry itself). A variety of technologies with low pay-back potential fall into this category, such as alternative fuel utilization, industrial waste utilization, and materials recycling technology. Industry will not support R&D in collaboration with competitors that addresses areas that can be defined as "competitive." Industry alone usually will selectively avoid R&D with a long-term expected pay-back period. Corporate investment horizons today for industry R&D expenditures are extremely short.

Metal Casting: The above benefits would not be realized without the DOE program because 80% of the 3,000 metal casting facilities employ less than 100 persons (small businesses) their ability to individually fund research needed for the competitiveness of the industry is weak. The DOE Metal Casting Competitiveness Program, required by Public Law 101-245, identified this inability of the industry to fund research and the importance of the industry to the economy and national defense. The DOE program provides funds to lessen the risk and cost of needed research while requiring 50% non-federal cost share for all projects. The 50% provided by industry facilitates consortiums of small businesses joining together on a research project.

Forest Products: In the absence of DOE funding, it is very likely that these projects would either not have been funded or been funded at a lower level. These projects reflect one or more of the following situations: the cost of R&D is too high for an individual company to recuperate; the risk of successful commercialization is too high; the anticipated benefits are difficult for an individual firm to capture; or the public benefit far outweighs the private benefit.

Aluminum: In the absence of DOE funding, the research and development projects co-funded by the Office of Industrial Technology would be delayed or deferred by private industry. See documentation for #283c. Similar documentation for the U.S. Department of Commerce's Advanced Technology Program (ATP) has been reported (April, 1996, *Journal of Metals*). The result of a survey of 125 companies and non-profit organizations participating in ATP projects was presented. According to the survey, 70 percent of the companies interviewed reported that there was little or no chance they would have pursued the technology now under development had they not received support through the ATP. Of the balance, 90 percent reported that they would have pursued goals at a much slower pace without government funding.

Glass: The industry is highly competitive and very diverse. Opportunities to work collaboratively between sectors of the industry and within sectors on common precompetitive research has not existed prior to the Glass Vision program. Due to the capital intensive nature of the industry and the reduction of R&D capabilities in-house, a program that pulls together multiple resources from industry and government will create successes that can not be achieved independently. Most R&D is currently happening overseas, which is pulling market share out of country.

Chemicals: Industry acting alone typically will not pursue energy conservation R&D that carries high technical risk or requires large capital expenditures. Industry will also not perform R&D that responds to improving the public benefit (even though there could be some positive benefit to the industry itself). A variety of technologies with low pay-back potential fall into this category, such as alternative fuel utilization, industrial waste utilization, and materials recycling technology. Industry will not support R&D in collaboration with competitors that addresses areas that can be defined as "competitive." Industry alone usually will selectively avoid R&D with a long-term expected pay-back period. Corporate investment horizons today for industry R&D expenditures are extremely short.

The chemical industry has some very large companies but the majority of firms are small businesses. The latter have neither the financial or technical expertise to perform long-term, high-risk research on their own. The government needs to play the crucial role in bringing together the innovativeness of business, the scientific expertise of both the national laboratories and academia on research needs for which there is no short-term pay back.

Q285. On page 462 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "In the chemical and petroleum refining industries, OIT-sponsored technologies such as production of petrochemical feedstocks from renewable resources, new membranes, improved catalytic processing techniques, advanced fluid catalytic cracking, and various new pollution prevention methods could help cut annual energy costs in these industries by more than $3 billion/year."

Q285a. Please provide detailed documentation of this claim, including the peer review process undertaken.

A285a. The energy and economic benefits reported for the Chemicals and Petroleum Refining industry programs derive from a three-step process, as follows:

QM Sector Analysis: OIT conducts detailed, project-level analysis of the energy, economic, and environmental characteristics for each of the technology research and development projects it funds. Analysis is performed using a computer-based modeling tool called the OIT Project Benefit Analysis Worksheet that was developed specifically for this purpose. The modeling tool enables OIT to compare the predicted technical and market performance of new, energy-efficient technologies with the current state-of-the-art technology alternative by assessing their relative costs, energy use (by fuel type), waste reduction. and market performance. The model employs standard financial evaluation methodologies to compare alternate technology investments over the lifetime of the technology, including the internal rate of return for a technology investment.

Data required to compare technology investments is obtained from research performers, equipment users, industrial studies, government-collected data, and manufacturers. These data are reviewed by several DOE experts in the appropriate technology area to verify that the information is accurate and sound. The model calculates a project's expected energy and cost savings based on the fuels displaced/used (by type), fuel-specific energy costs, relative capital and operating costs, non-fuel production cost savings, equipment life, size of the market, the market penetration rate, and other project specific information. Energy costs savings are calculated based on the type and amount of fuel saved and the cost of that fuel for the industrial sector. Fuel costs are based on national surveys of fuel expenditures for each state as reported by the Energy Information Administration. Environmental benefits include the reduction in combustion-related emissions that are avoided by employing the more energy-efficient technology. They are calculated using the amount of fuel combustion avoided and their associated emissions loadings (SO_2, NO_x, CO_2, etc.). Energy, cost, and environmental benefits reported for a specific program represent the aggregated benefits of the individual projects included within that program.

QM Integrated Results: In addition to the rigorous sector analysis conducted, the Quality Metrics process uses an integrated model to perform an equilibrium analysis to estimate sector totals. By using an integrated model, interactions between programs within a sector can be accounted for (for example efficiency programs reducing electricity demand) and double counting can be eliminated.

Quality Metrics peer review: EERE contracted with Arthur D. Little (ADL) to design and implement an external peer review process of these estimates. ADL examines technology assumptions and the resulting market penetration of EERE technologies.

Most of the high impact and high uncertainty programs have been reviewed, and ADL is currently completing the review of the remaining technologies.

A few of the more important elements that are computed are provided in Tables 1 (Refining) and 3 (Chemicals). The information that is computed in this first step is then used to calculate the information provided in Tables 2 (Refining) and 4 (Chemicals), below. Because of the uncertainties involved in calculating these numbers, a conservative estimate of $3 billion (derived process) was used for the Congressional Budget Request statement noted above.

Some of these projects (such as the Active Transport Membrane and Ethanol from Refining Wastes) were established through cooperative agreements (10 CFR 600, Financial Assistance) between DOE and a private sector organization, and were the result of publicly announced solicitations and/or awards seeking proposals for advanced technologies that would demonstrate ways to improve the energy efficiency and/or minimize waste production in the energy intensive chemical processing systems utilized in the chemicals and petroleum refining industries. The merit review procedures established in 10 CFR 600 were utilized in selecting the best proposals for funding.

Projects being funded at DOE National Laboratories (such as the Catalysts with Improved Selectivities and Emissions/Petroleum Environmental Research Forum projects) were selected on the basis of demonstrated capabilities of the laboratories to conduct research responsive to industry-defined needs.

Q285b. Please document why this benefit would not occur in the absence of DOE funding.

A285b. All of these projects were selected on the basis of competitive awards through an assessment process that is responsive to the public benefit. Industry acting alone typically will not pursue energy conservation process R&D that carries high technical risk or requires large capital expenditures. Industry also will not perform R&D that responds to improving the public benefit (even though there may be some positive benefit to the industry itself). A variety of technologies with low payback potential fall into this category, such as alternative fuel utilization, industrial waste utilization, and materials recycling technology. Industry will not support R&D in collaboration with competitors that addresses areas as defined as "competitive," and which would be available to industry members as a group. Industry alone usually will selectively avoid R&D with a long-term expected payback period. Corporate investment horizons today for industry R&D expenditures are extremely short.

Perhaps a real-life example would be illustrative of the points made above. OIT and Chemical Research & Licensing. Inc., (CR&L, A NOVA Subsidiary, 10100 Bay Area Blvd., Pasadena, Texas 77507) developed a new, single-stage catalytic reaction/distillation process for production of gasoline additives such as methyl tertiary butyl ether (MTBE), and tertiary amyl methyl ether (TAME). In comparison to the conventional, multi-stage process, the new catalytic distillation process is more energy efficient and also lower in capital cost. The new process saves energy since heat re-leased by the equilibrium reaction is used directly for distillation, eliminating external heat exchange and its consequent energy losses.

The first commercial application of the catalytic distillation process was in a Charter Oil refinery in 1981. DOE's role in this commercialization activity was to guarantee the catalyst that was used in the test unit. The first batch of catalyst was "poisoned"–DOE funded the second batch of catalyst, which operated successfully. Without DOE support the development of this new technology would have been terminated following the failure of the first test.

Chemical Research & Licensing (CR&L), founded in 1976 (4 persons), has grown to 75 employees, with 25 jobs directly related to the MTBE technology development and the remainder devoted to catalytic processes for other ethers, aromatic alkylations and hydrogenations. ABB Lummus Crest provides engineering support with an 8-person core group that increases to 20 depending upon sales and engineering package production requirements. In addition, a cottage industry supporting from 40-60 additional jobs has been created to make the fiberglass bags to contain the catalyst. CR&L, together with Neochem Corporation, jointly developed with DOE support a catalytic distillation process for etherification of isobutylene with methanol. This unit was the world's first to produce this octane booster exclusively from crude refinery feedstocks. This demonstration was the critical step in facilitating licenses to Amoco and Exxon in 1985. Since then CDTECH, a partnership between CR&L and ABB Lummus Crest Inc., has licensed this technology to over 60 different companies worldwide, and is in the process of negotiating 40 additional licenses. As part of the cooperative agreement with DOE $200,000 was paid back to the government (1986) with revenue generated from licensing income. MTBE is an EPA-approved octane builder additive for gasoline. This technology has garnered 28% of the world market in MTBE and TAME. As of FY 1993, 31 units were in operation, 19 of which are located in the U.S.

PROJECTS INCLUDED IN QUALITY METRICS ASSESSMENT OF ENERGY AND ECONOMIC BENEFITS FOR THE REFINING INDUSTRY PROGRAM

Table 1

	Year 2000				Year 2010			
Project	Energy Displaced, Quads	Market Penetration Rate (Units), %	Capital Cost $MM	Operating Cost $MM	Energy Displaced, Quads	Market Penetration Rate (Units), %	Capital Cost $MM	Operating Cost $MM
Active Membrane Transport	0	5.88	0.5	0.390	0	6.0	0.5	0.390
Catalysts with Improved Selectivities	0	0	0	0	0.007	0.43	1.02	3.995
Develop Superior Asphalt Recycling Agents	0.238	32.7	0.005	0.085	0.180	25.18	0.005	0.085
Emissions/ PERF	0	0.56	1.0	0	0	3.67	1.0	0
Ethanol from Refining Wastes	0.023	3.85	31.0	8.2	0.607	100	31.0	8.2
Hi Temp Catalytic Ceramic Membrane	0	2.43	2.5	0	0	27.34	2.5	0
Inorganic Membranes-Methanol Markets	0	0	0	0	0.003	33.33	402	101
Inorganic Membranes-MTBE, Styrene and Propylene Markets	0	0	402	101	0.005	2.25	402	101
Steam Methane Reforming	0.001	8.33	124	5.51	0.007	50	124	5.51

Petroleum Refining Vision
Quality Metrics Summary of Impact
February 21, 1996
Table 2

Project	Year 2000	Year 2010
Total Primary Energy Displaced, Quadrillion Btu	0.211	0.649
Primary Oil Displaced, Quadrillion Btu	0.207	0.521
Energy Cost Savings, Billions of 1995$	1.21	3.92

PROJECTS INCLUDED IN QUALITY METRICS ASSESSMENT OF ENERGY AND ECONOMIC BENEFITS FOR THE CHEMICALS PROGRAM

Table 3

	Year 2000				Year 2010			
Project	Energy Displaced, Quads	Market Penetration Rate (Units), %	Capital Cost $MM	Operating Cost $MM	Energy Displaced, Quads	Market Penetration Rate (Units), %	Capital Cost $MM	Operating Cost $MM
Advanced Moisture Sensor-Harvesting	0	4.2	0.025	0.001	0	25.0	0.025	0.001
Advanced Moisture Sensor-Processing	0	4.5	0.297	0.02	0	10.0	0.297	0.297
Auto Shredder Residue	0	50.0	1.9	0.2	0	50.0	1.9	0.2
Biological-Chemical Caprolactam Production	0.003	21.3	0.3	0.9	0.012	99.9	0.3	0.9
Biomass to Lactic Acid	0.09	3.0	189.3	75.2	0.11	3.0	189.3	75.2
Bioprocessing Systems	0	0	0	0	0.016	80.0	60.0	43.4
Catalytic Gasification	0	2.42	5.86	1.2	0.002	11.4	5.86	1.2
CO2 Dry Cleaning	0	0.04	0.06	0.002	0	0.32	0.06	0.002
Electroplating Waste Minimization	0	0.5	0.95	0.32	0.027	30.0	0.95	0.32
Enzymatic (Biocatalytic) Hydration	0	0	0	0	0.003	38.9	48.0	23.4
Food Waste to Lactic Acid	0.827	29.1	53.3	24.5	0.53	100	53.3	24.5
Hydro-benzoic Acid	0.001	33.3	79.6	18.0	0.001	66.7	79.6	18.0
Inorganic Polyphos-phazene Membranes	0.005	2.63	0.76	18.0	0.039	19.7	0.76	18.0
Phenolics from Wood Wastes	0.01	46.2	46.0	9.7	0.008	31.3	46.0	9.7
Recovery Chlorosilane Intermediates	0	50.0	908.0	424.3	0	25.0	908.0	424.3
Scrap Tire Recyclng	0.14	46.7	9.0	10.0	0.14	46.7	9.0	10.0

Chemicals Industry Vision Quality Metrics Summary of Impact February 21, 1996 Table 4		
Project	**Year 2000**	**Year 2010**
Total Primary Energy Displaced, Quadrillion Btu	1.7	1.3
Primary Oil Displaced, Quadrillion Btu	0.92	0.75
Energy Cost Savings, Billions of 1995$	7.6	6.8

Q286. On page 462 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is also stated: "In the forest and paper products industry, OIT . . . technologies have the potential to reduce the industry's energy use by more than 500 trillion Btu/year and reduce its annual energy bill by more than $2 Billion. Recovery boiler modeling should improve the efficiency of and control over the combustion and chemical reactions occurring in the Tomlinson boiler and help reduce combustion-related CO2 emissions by nearly 5 million tons/year."

Q286a. Please provide detailed documentation of these claims, including the peer review process undertaken.

A286a. OIT is in the process of conducting detailed, project-level analysis of each project funded using a calculational modeling tool called the "OIT Project Benefit Analysis Worksheet" developed specifically for this purpose. The data for each project is initially prepared by the research performer, and then is reviewed by several DOE experts in the technology area to verify that the information provided is realistic and/or correct. The model calculates a project's energy and related cost savings (versus the state-of-the-art existing technology) based on fuel type used/displaced, sector-specific energy costs, size of market, market penetration rate, and other project-specific information. At the time the 1997 budget was prepared, about one-third of the projects in the Forest Products vision area had been analyzed using this model. The values of "over 500 trillion Btu" (i.e., over 0.5 quads) and $2 billion energy cost savings were obtained by extrapolation to the remaining two-thirds of the projects in proportion to their budgeted value. All projects in the Forest Products vision areas will be analyzed using this model by the end of 1996, which will produce a more accurate estimate of total anticipated energy and cost savings.

The OIT Project Benefit Analysis model mentioned above has been completed for the Recovery Boiler Model project conducted by the Institute for Paper Science and Technology (IPST). The model calculates combustion and non-combustion related emissions based on fuel type(s)used/displaced, fuel-specific emission factors, raw materials used/displaced/recycled, waste generation, size of market, market penetration rate, and other project-specific information. Based on this analysis, the project will save close to 5 million tons of combustion-related CO_2 emissions per year by the year 2010.

Q286b. Please document why these benefits would not occur in the absence of DOE funding.

A286b. In the absence of DOE funding, it is very likely that the projects funded in the Forest Products vision area would either not have been funded or been funded at a lower level. These projects reflect one or more of the following situations: the cost of R&D is too high for an individual company to recuperate; the risk of successful commercialization is too high; the anticipated benefits are difficult for an individual firm to capture; or the public benefit far outweighs the private benefit.

The Recovery Boiler Model project is being conducted by the Institute for Paper Science and Technology, which is an accredited university. The EPST, like most higher education institutions in this country, is very dependent on programs like OIT's for funding to support basic and applied research and the educational base. Because of the high initial risk of this technology, and the fact that the benefits are difficult to capture by a single company, industry was unlikely to support the recovery boiler model project

Q287. On page 463 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "For the metals and glass industries, OIT's supported steel industry technologies offer the potential to reduce energy use by about 200 trillion Btus/year and cut annual energy costs by more than $1 billion. OIT steel technologies also can provide substantial environmental benefits. For example, the electrochemical removal of zinc from steel scrap could enable nearly 1 million tons of off-grade scrap to be recycled and steel plant dust and sludge recycling could reduce the industry's solid waste by more than 3 million tons/year while lowering its environmental costs. In the power-intensive aluminum industry, improved alumina calcining, inert anode/cathode reduction cells, and spray forming could help reduce energy use by about 300 trillion Btu/year and reduce the industry's energy costs by more than $900 million/year. OIT's metal casting industry technologies not only reduce energy use, but also cut down on solid waste generation. For example, the foundry sand mobile recycling unit could cut the industry's annual disposal of spent sand by more than 2 million tons/year. OIT glass industry projects, such as the advanced glass temperature sensor, oxygen enriched air staging side-port demonstration, and cullet/batch preheater, offer potential energy savings of 0.05 quad at a cost savings of about $180 million."

Q287a. Please provide detailed documentation of these claims, including the peer review process undertaken.

A287a.

Steel: Electrochemical removal of zinc from steel scrap could enable nearly 1 million tons of off-grade scrap to be recycled and steel plant dust and sludge recycling could reduce the industry's solid waste by more than 3 million ton/year, while lowering its environmental costs. The energy savings are based upon two factors: (a) a reduction in the energy required to produce hot metal from dezinced scrap rather than primary ore, and (b) estimates of the market for this technology.

The market penetration is estimated to be 4.5 million ton, or less than one half of the galvanized scrap available by the year 2000. The energy conserved by this technology is based on 16 million Btu/ton now required to produce hot metal from primary ore. The dezincing technology will require 5 million Btu/ton to produce hot metal from clean scrap: (16 million Btu/ton-5 million Btu/ton) = 11 million Btu/ton savings x 4.5 million tons market potential = 49.5 trillion Btu.

The estimate of raw material savings is now about $140 million based on a reduction in the price of raw materials in recent years. The dezincing technology will produce clean degalvanized scrap that can be used to produce hot metal rather than the use of primary ore. The market penetration rate is assumed to be 4.5 million tons and the cost difference between hot briquetted iron (HBI) and the price of prime grade automotive scrap is about $30/ton. The savings therefore is $30/ton x 4.5 million tons, or $135 million. The U.S. imports about 700,000 tons/year of zinc. The zinc removed from the estimated approximately 5 million tons of galvanized scrap is estimated to be 1.5% by weight or 75,000 tons. This estimate has now been increased to 100,000 ton based on recent studies of the market available.

Aluminum:

Calcining: Reduced energy consumption of up to 20.3% have been shown in bench scale tests of this technology. The energy savings include the credit for the steam produced less the cost of power replacement. Based on a 100% market penetration rate the annualized energy savings are 10 trillion Btu/year. If an average energy cost of $3.00/mmBtu is assumed the energy cost reduction will be $30 million. The project was awarded based on an unsolicited proposal submitted by the participant. A formal merit review process was conducted and concurrence of the estimated energy savings was obtained.

Inert-anode/cathode reduction cells: The passage of current between the anode and cathode in an electrolytic cell consumes much of the energy used in aluminum production. The potential energy savings are 30% of the total energy consumed in the manufacturing process and will save $0.027-0.05/lb of aluminum. The use of inert cermet anodes will reduce energy consumption in the U.S. aluminum industry by 100 trillion Btus. The project was awarded based on an unsolicited proposal submitted by the participant. A formal merit review process was conducted and concurrence of the estimated energy savings was obtained.

Spray forming: Energy savings of 27% compared to conventional ingot casting and cost savings of $0.02/lb of finished sheet aluminum are estimated. These savings total 0.19 quad/yr from the application of the concept to the manufacture of lighter components for domestic automotive applications. The project was awarded based on an unsolicited proposal submitted by the participant. A formal merit review process was conducted and concurrence of the estimated energy savings was obtained.

The above three projects are estimated to save 300 trillion Btu/yr. If energy is assumed to be $3.00/mmBtu (energy user news publication), the annual energy savings amount to $900 million/yr. Recent price increases since this estimate was made. if incorporated, would increase this estimate.

Metal Casting: The foundry sand mobile recycling unit could cut the industry's annual disposal of spent sand by more than 2 million tons/yr. If implemented at full market capacity, 400 transportable units will be incorporated with an average reduction in sand disposal of 5,400 tons/unit, totaling 2.2 million tons/yr.

Glass: These benefits encompass the targets identified by industry at the time the 1997 budget was developed. In the Glass Vision process, OIT asked industry what R&D areas would be a priority for them based on how they would want to look, as an industry, in 2020. In order to be a viable industry in the year 2020, they identified these targets as priorities for their industry. For example, an estimation of bringing all glass facilities 50% closer to ideal energy consumption from where they were in 1995 averages out to a minimum of 20%. Some companies are operating at 6-8 million Btus of energy to melt one ton of glass, where theoretical lies at 2.2 million Btus. In light of energy losses, an improvement to 3.5 million Btus is a probable ideal energy consumption. These targets have been more clearly defined in the Glass Industry Vision, which will be signed by representatives from the industry and the Secretary of Energy on April 29, 1996.

Q287b. Please document why these benefits would not occur in the absence of DOE funding.

A287b. **Electrochemical removal of zinc from steel scrap:** DOE funding supported Argonne National Laboratory participation which was critical in the development of this technology. Argonne provided chemical processing development expertise and analytical capabilities not existent in the private sector. By themselves, the owners of the technology had a hard time finding venture capital at terms that meet their acceptance. The sponsorship by DOE has been an attractor for obtaining outside capital. Degalvanizing was identified by ANL in 1987 as potentially a government project through the DOE Office of Industrial Technologies Waste Reduction program. Private enterprise has always stated that the length of time to complete R&D and arrive at the start of commercialization did not made this project profitable for the companies. No corporation would be willing to wait for payback (1987 to present). Private enterprise has always stated that success was contingent upon obtaining DOE funding (of near 50%) to support the research and development stages of the technology so that the risk of development would be lowered sufficiently such that venture capital would be made available.

Aluminum: The DOE-supported aluminum technologies discussed are considered "high risk" by the conservative, capital intensive aluminum industry. Consequently, without DOE providing a significant portion of the cost in demonstrating the technical and economic feasibility of the process this technology would not have been developed.

Metal Casting: The main use of the mobile sand reclamation unit was for the. regional use of small foundries without the throughput of sand per foundry needed to make the capital expense of a fixed reclamation unit feasible. These small shops would not be able to fund this research without the partnership with DOE.

Glass: The industry is highly competitive and very diverse. Opportunities to work collaboratively between sectors of the industry and within sectors on common precompetitive research has not existed prior to the Glass Vision program. Due to the capital intensive nature of the industry and the reduction of R&D capabilities in-house, a program that pulls together multiple resources from industry and government will create successes that can not be achieved independently. Most of the current R&D has been happening overseas, resulting in losses of the market share to foreign competition.

Q288. On page 463 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the FY 1995 Accomplishment Summary states: "Visions of the Future strategies have been completed with the Forest Products Industry and Steel Industries. These partnerships between government and industry were signed by the Secretary of Energy and representatives of the industry."

Please provide copies of (i) these two Vision of the Future strategies and (ii) both signed agreements.

A288(i) Attached are (i) copies of the Vision of the Future strategy for the forest products industry entitled *Agenda 2020: A Technology Vision and Research Agenda for America's Forest, Wood and Paper Industry*, and the Vision of the Future strategy for the steel industry, entitled Steel, *A Natural Resource for the Future.*

A288(ii) Copies of the signed agreements are attached.

Agenda 2020

A Technology Vision and Research Agenda for America's Forest, Wood and Paper Industry

November 1994

Background

This Technology Vision and Research Agenda was developed by the Chief Technical Officers of the forest, wood, pulp and paper industry, with advice from research institutions and other organizations. Guidance was provided by the industry leadership through a committee of Chief Executive Officers.

The Association Board of Directors, at their meeting on October 14, 1994, approved this document and authorized the work needed to develop an implementation plan for the Research Agenda in collaboration with agencies of the federal government and the major institutions with expertise in the field.

Issued: November, 1994

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GLOSSARY OF ACRONYMS

AF&PA	American Forest & Paper Association
DOE	United States Department of Energy
FPS	Forest Products Society
NCASI	National Council for Air & Stream Improvement
R&D	Research and Development
RPTA	Recycled Paperboard Technical Association
TAPPI	Technical Association of the Pulp and Paper Industry

AMERICA'S FOREST, WOOD AND PAPER INDUSTRY

LOOKING TO THE 21ST CENTURY: A TECHNOLOGY VISION AND RESEARCH AGENDA

EXECUTIVE SUMMARY

This document presents the forest, wood and paper industry's perspective of where the industry stands today, a desired state for the industry twenty-five years into the future, and the technology-related issues that must be addressed to accomplish the industry's vision of the future.

In many respects, this document represents a bold step forward for the industry. Never before has the industry with such unanimity taken a look at its future, the need for technological development, and ways to leverage its own capabilities with partnerships involving institutions, suppliers, and government.

Recognizing the inability of humans to accurately predict the future, the focus is on direction and broad, general goals rather than specific endpoints and solutions. Trying to predict the future with specificity always results in a presentation of the authors' biases and preconceived solutions to current problems. This report focuses, instead, on identifying major strengths and weaknesses of the industry and pressures from outside. Flexibility and multiple pathways towards the elements of the vision are believed to be essential, providing ability to adapt to a changing environment and unforeseen events.

Realizing that when we look ahead as far as the year 2020 our vision can hardly be 20/20, we must be prepared to re-evaluate our perspective periodically–perhaps every 3-5 years.

The Importance of the Industry to the Nation

The forest, wood and paper industry is a worldwide leader, globally competitive and an important contributor to the nation's economy. Employing 1.4 million people directly and producing products valued at more than $200 billion per year, it ranks among the nation's top 10 manufacturing industries.

The wide array of products provided by this industry are safe, functional and, in many respects, essential to the everyday needs of citizens, government and other institutions. At home, paper products provide the bases for communications (through books, newspapers, notepaper and artwork), convenience and improved sanitary conditions (through paper towels, facial tissues, and disposables). Specialty papers provide protection to machines and to people through seals, gaskets, and filters. Paper and paperboard packaging materials protect and conserve all manner of products from production through distribution to end use.

After use, wood and paper products can be recovered for recycling, composting or conversion to energy. The industry has long been a leader in recovery and recycling. Paper is among the most intensively recycled materials in our society. Some 40% (or about 36 million tons per year) of all the paper used in the U.S. is currently being recovered for recycling. The industry intends to increase this rate to 50% by the year 2000.

Trees provide the major raw material for this industry, necessitating a commitment to sustainable forestry. Recognizing the importance of this raw material base for long range survival, companies in the industry have a long standing reputation for being stewards of America's forests. Today, the U.S. has far more trees than in the 1920s and grows over one-third more wood than is used and lost to natural causes each year. Among the many favorable attributes of healthy, productive forests are: a favorable impact on the atmospheric carbon dioxide balance, preservation of soils, and protection of animal habitats. Wood also provides a source of clean, renewable energy.

Pressures on Performance and Competitiveness

In spite of the success of the forest, wood and paper industry, it has significant challenges ahead in meeting the changing standards of society while remaining economically viable and globally competitive.

The industry's most valuable asset, an abundant and low cost raw material base, is being challenged by developments both domestically and abroad. Land available for growing commercial wood is diminishing, and pressures are building to remove even more public lands from commercial production. In addition to driving up prices, this puts pressure on the industry to use lower quality wood which can in turn result in higher energy usage. For example, the reduced availability of large timber has shifted wood-based building materials towards engineered products which are more energy and capital intensive.

While recycling reduces the pressures on virgin fiber supply, further increases in recycling will require that lower grades of recovered fiber must be used, or this lower quality fiber must find uses in high quality finished products. Historically, most recycled fiber has been used in less demanding applications. Upgrading low quality recovered material is both costly and energy intensive.

The industry is also being increasingly challenged from abroad. In addition to traditional competitors such as Canada and the Scandinavian countries, which have always placed a high value on forest product exports, challenges are coming from new areas. With government subsidies, low-cost wood and cheap labor, countries such as Chile, Indonesia, Brazil, and South Africa are rapidly becoming the world's low cost producers. Technological leadership, once clearly owned by the U.S. industry, has also been shifted towards Canada and the Scandinavian countries over the past 20-30 years.

More demanding environmental requirements are also a major burden that the U.S. industry must bear over the next decade and beyond. To comply with a wide range of new regulatory initiatives, the industry is facing unprecedented increases in capital expenditures, operating costs and energy use.

The pulp and paper industry is the nation's most capital intensive manufacturing industry and is among the most energy intensive. Currently, the industry is 57% energy self sufficient; up from 36% in 1972–a substantial achievement. However, in spite of tremendous progress, long-term viability demands improvements in energy and capital efficiency if financial performance is to be enhanced and reach satisfactory levels.

The Industry's Vision for the Future – 2020

The U. S. forest, wood and paper industry will continue to be the global leader in providing safe and essential products based on forest resources. The industry must be financially healthy and attractive not only to the investment community but also to the communities in which it operates and the nation as a whole. It will be an example of sustainability with its renewable raw material growing in productive, well-managed forests at rates considerably greater than today. The virgin raw material base will be increasingly leveraged with material recovery and recycling.

Manufacturing plants will operate in harmony with the environment and the communities in which they are located. Water use will be low and discharges to the air and water will be closely controlled to minimize effects on the environment. Regulations will take into account environmental effects as well as energy use and economics.

More energy efficient processes will evolve and an even larger amount of the industry's energy will be self generated based on biomass and waste materials, with excess energy marketed in the form of electricity and liquid fuels.

Productivity will be substantially higher than today, and less costly processes will be developed, improving capital efficiency and leading to enhanced financial performance.

Highly skilled and motivated employees will operate the industry's automated manufacturing facilities. Worldwide technological leadership will be regained as the best scientists and engineers are attracted to the industry and cooperative pre-competitive efforts between the industry, universities, and government flourish.

The Long-Range Research Agenda

Comparing the vision of the future with the current state of the industry leads to a number of research needs. This technology vision and research agenda discusses those needs that will advance the entire industry and are also suitable for cooperative research efforts. High priority efforts will include the areas of:

- Sustainable Forest Management
- Environmental Performance
- Energy Performance
- Improved Capital Effectiveness
- Recycling
- Sensors and Control

Each of these research areas is relevant to all three industry segments–forestry, wood products, and pulp and paper products. This research agenda also covers a spectrum of program maturities, from basic research to development and demonstration projects.

Specific product research and development areas are not addressed in this agenda. Although product development is essential to the long term success of the industry, it is a primary basis for competition among companies and is best left to the individual efforts of company proprietary research and development programs. However, studies of the fundamental chemical and physical characteristics of fibers and fiber structures are included. Individual company researchers and product developers should use the results of this fundamental research to advance proprietary product development and to promote competition.

The Need for a Cooperative Research Program

America's forest, wood and paper industry is facing rapidly accelerating worldwide competition. In addition, complexity is increasing due to changing societal values and interaction of many competing pressures. Many of the research needs facing the industry today are industry-wide and too costly and complex to be handled by individual companies alone. Global competition has forced rationalizing of the industry's long-range, generic research capabilities, making scarce resources too valuable to be wasted with duplication of efforts. Now is the time for the industry to partner with government, suppliers, national laboratories and universities to leverage all available resources. Successful efforts to address the major technological issues discussed in this document will ensure the continued success of one of America's most important basic industries.

Developed by the industry's Chief Technology Officers
under the guidance of a Chief Executive Officers Working
Group for the American Forest & Paper Association

Date: September 26, 1994

AMERICA'S FOREST, WOOD AND PAPER INDUSTRY

LOOKING TO THE 21ST CENTURY: A TECHNOLOGY VISION AND RESEARCH AGENDA

1. INTRODUCTION

The U.S. forest, wood and paper industry represents one of the country's greatest assets. The industry is globally competitive and attractive from the standpoint of sustainability and environmental compatibility. In many ways this industry is an ideal example of a desirable, self-sustaining industry which should be supported by the nation. In addition to generating hundreds of thousands of productive, well-paying jobs and creating wealth shared by many, the industry:

- produces safe, essential products that contribute to improved quality of life and efficiency of government and business;
- is based on a renewable and sustainable raw material;
- produces products which are recycled, composted, converted to energy and are bio-degradable;
- achieves substantial levels of recovery and recycling;
- is based on integrated energy production from residual materials and is a positive contributor to the nation's renewable energy goals;
- contributes favorably to the global carbon balance;
- contributes to forest health through land management, reforestation and conservation of habitats;
- provides sporting opportunities and recreational areas for the public; and
- employs manufacturing processes which use extensive recovery, recycling and pollution prevention methods.

In spite of these desirable characteristics, the industry faces significant challenges ahead in meeting the changing standards of society while remaining economically viable and globally competitive. The industry has and will continue to undergo change over time. Its high capital intensity and the resulting economic consequences of equipment replacement tend to limit experimentation, development and application of large, new core technologies, particularly in the pulp and paper segment. In a rapidly changing environment with increasing social, regulatory and consumer expectations, it is imperative to encourage technological innovation to meet these challenges. At times, these changing expectations exceed the industry's capability to respond and, therefore, require broader collaboration among all stakeholders.

This document provides an overview of the major technology options needed to accomplish the industry's vision. By addressing the needs identified below–through a partnership with government, the industry's stakeholders, public and supporting laboratories and institutions—the continued success of one of America's most essential and desirable industries can be assured.

2. BACKGROUND

The federal government has been investing in the competitiveness of American industry for many years. The forest, wood, and paper industry has participated in this funding to a lesser extent than other industries (notably textiles, automotive, and semi-conductors).

During the past year, the U.S. Department of Energy has been encouraging the industry to develop an industry-supported vision for the future which could be used to better direct government investments in R&D to important industry needs. The DOE is also encouraging the industry to develop a coordinated effort to take advantage of, where appropriate, the $10 billion a year currently being invested by the federal government on industrial research.

The AF&PA, supported by NCASI, RPTA, FPS, and TAPPI, has been identifying the major long-term technological needs and challenges that could have significant impact on the industry 20–30 years in the future. Since perfect vision into the future is impossible, this document should be reviewed and updated regularly, perhaps every 3–5 years. It is hoped that the information assembled here will be useful to: (1) advance the fundamental research needs of the industry; (2) provide a basis for allowing individual companies to become more globally competitive; (3) assist the industry and government funding agencies in allocating research funds to the most important research needs; and (4) serve as a basis for communication with government agencies to expand government/ industry partnerships.

The process of developing the industry's technology vision and research agenda has been led by a CEO level working group headed by the Chairman of AF&PA and composed of CEOs representing the full range of industry products and interests. Drawing on earlier work by the AF&PA Energy Council, the CEO group empaneled and guided the efforts of a broad-based Chief Technology Officers' working group to expeditiously refine and finalize an industry research agenda. The input from over thirty institutions supporting industry research was obtained at a workshop held in August (see Appendix). In early September, the CEO leadership group approved the document for discussions with the DOE and for presentation to the AF&PA Board of Directors.

3. THE FOREST, WOOD AND PAPER INDUSTRY TODAY

A. Industry Overview

The American Forest & Paper Association is the national trade association of the forest, pulp, paper, paperboard, and wood products industry. AF&PA represents approximately 425 member companies and related trade associations (whose memberships are in the thousands) which grow, harvest, and process wood and wood fiber; manufacture pulp, paper, and paperboard products from both virgin and recovered fiber; and produce solid wood products. As a single national trade association, AF&PA represents a vital national industry which accounts for over 7% of the U.S. manufacturing output. Its members account for more than 90% of the domestic paper and recycled paper manufacturing capacity.

For more than three centuries, the forest, wood and paper industry has made a vital contribution to the realization of the American dream. The industry has framed houses, finished offices, built containers, packaged goods, spanned rivers, held rails straight, carried news, provided sanitary products; it has provided products for great corporations and small businesses, picnics and political rallies and produced paper for magazines and newspapers, novels and encyclopedias, poetry and art. Generations have been entertained with jigsaw puzzles, paper airplanes, paper dolls and ice cream sticks.

The industry has employed countless millions of working men and women in thousands of mill communities across the nation, bringing growth and vitality to local communities, creating a dependable tax base to build schools and roads and theaters, and public works of every description.

Above all, the forest, wood and paper industry has tried to keep the forest in perspective, not only as an essential basis for industry, but as the handiwork of nature's life cycle, constantly renewing and replenishing itself for the multiple uses of man and wildlife.

Today, the forest, wood and paper industry produces wood and paper products valued at more than $200 billion each year with contributors ranging from large, state-of-the-art mills to small family-owned sawmills and some 7 million individual woodlot owners.

It employs 1.4 million people directly and ranks as one of the top 10 manufacturing industries in 46 out of 50 states.

B. Forestry

A healthy and productive forest is essential for the forest, wood, and paper industry. Today, the U.S. has far more trees than in the 1920s and grows over one-third more wood than is used and lost to natural causes each year.

In 1993, 1.7 billion seedlings were planted in the U.S.; 43% were planted by forest products companies which own only 14% of the U.S. commercial timberlands. An acre of young, healthy, growing trees is capable of producing in excess of 4,000 pounds of wood in one year. These trees consume nearly 6,000 pounds of carbon dioxide during their growth, thereby sequestering carbon for long periods of time.

The industry's future depends on practicing responsible forest management principles for sustainable development to provide for both protection and efficient use of the nation's forests.

C. Wood Products

Wood products occupy a unique position in North American society. Because of its versatility, wood has been used extensively as an industrial material throughout the history and settlement of the continent.

Over 95% of all homes in the U.S. are built with wood-framed walls and roofs. Because wood is a sustainable, energy-efficient building material and is renewable, it is the basis for economic housing. The per capita consumption of wood in the U.S. increased over 30% from 1970 to 1987.

Expanding population and development creates much greater demand for energy conservation. Wood products are preferred over other materials because of low embodied energy and low thermal conductivity. Solid wood is 4 times more efficient as an insulator than cinder block, 6 times more efficient than brick, 15 times more efficient than concrete, and 1,770 times more efficient than aluminum. From raw material to the finished final product, steel studs take 9 times more energy to produce and transport than wood studs; aluminum siding takes 4 times more energy to produce and brick veneer 22 times more energy than wood siding; concrete floors take 21 times more energy to produce than wood floors.

Wood is effective in harsh conditions. Flexible frames "give" during earthquakes, preventing cracking and crumbling. Most of the wood-frame homes survived the 1994 Northridge, California earthquake with little more than cosmetic damage, and wood-frame structures built-to-code also survived Hurricane Andrew's winds.

To meet changing marketplace needs, wood-based products are being combined with other materials to produce advanced material composite products that have optimized characteristics.

D. Pulp and Paper Products

Diversity and change are inherent in the pulp and paper industry. The industry is characterized by both large high speed mills and by many small specialty mills. It is very significant on an international scale. Exports include wood pulp, kraft linerboard, and wastepaper. Major imports include wood pulp, newsprint, and printing and writing paper.

There are many facts and figures that underscore the breadth of the pulp and paper industry in the U.S. The pulp and paper industry includes 547 mills in 42 states, and produces 82 million tons of paper and paperboard and 10 million tons of market pulp. With only 16% of the world's pulp mills, the U.S. produces 35% of the world's pulp. Paper and paperboard are used to publish more than 2 billion books, 350 million magazines, and 24 billion newspapers in the U.S. annually. The U.S. mill output equals that of the next four top countries combined.

From an investment perspective, more than $120,000 of plant and equipment is invested on average for every industry employee, which is more than twice the average of other domestic manufacturing industries. U.S. companies have invested more than $100 billion since 1980 to raise productivity, quality, and underwrite expansion into new products and markets.

America's papermakers are fully committed to their paper recovery goal. A full two years ahead of schedule, the industry has reached its goal of recovery for recycling and reuse of 40% of all paper Americans use (that's 36 million tons) and has set a new goal of 50% recovery by the year 2000. There are about 550 facilities in the U.S. making paper, paperboard and building products. More than 400 of these facilities use recovered paper as a raw material for papermaking. More than 200 rely on it entirely. By the year 2000, expenditures aimed at increasing the industry's paper recycling capacity will have exceeded $17 billion over a twenty-year time period.

The industry has an impressive track record in the environmental and energy fields. It has reduced the amount of water used to produce each ton of paper by 70% over the past two decades and is significantly ahead of schedule meeting emissions reduction goals developed by the EPA. The industry voluntarily reduced dioxin discharges by 92% over the past five years, so that dioxin levels now cannot be measured in the wastewater of every nine out of ten bleached pulp mills, and 100% of mills will have undetectable amounts by 1996.

Industry spending for environmental improvement exceeds $1.0 billion per year, which currently is an estimated 20% of capital spending—a percentage which is anticipated to increase dramatically by the end of this century.

The industry each year consumes approximately 3 quads of energy to make its products and has made significant progress in both energy use and self sufficiency over the last 20 years—currently operating at 57% self sufficiency, up from 36% in 1972. In spite of the above statistics, the industry is still the fourth largest user of fossil fuels in the industrial sector.

E. Global Competitiveness Issues

The U.S. forest, wood and paper industry is currently ranked as one of the most competitive in the world, exporting over $17 billion worth of products in 1993. With the 1993 implementation of the North American Free Trade Agreement (NAFTA) and agreement in the Uruguay Round of multilateral trade negotiations (GATT) to reduce or eliminate tariffs by 2005, long-term prospects for U.S. exports of wood and paper products should improve markedly. However, to realize its full potential, the U.S. industry must remain competitive in raw material supply, compete effectively with the threat of new materials, operate in harmony with the environment, and strengthen its image as a good investment with its stake holders and as a good corporate citizen with the public.

Consider these statistics that reflect both the global competitiveness opportunities and threats to this industry:

- U.S. wood products valued at $7.3 billion were exported in 1993, $2.3 billion of which was softwood and hardwood lumber. Because of tightened lumber supply in the Pacific Northwest and fewer overseas log exports, imports valued at $8.3 billion surpassed exports.
- Exports of U.S. pulp and paper products were also considerable in 1993, totaling $9.6 billion. The relatively strong economic growth in the U.S., coupled with recessions in major industrialized countries, created a surge of paper and paperboard imports into the country. U.S. pulp and paper imports were valued at $10.6 billion.
- The largest wood products export markets for the U.S. in 1993 were Japan ($3.2 billion), European Union ($1.2 billion) and Mexico ($474 million). For pulp, paper and paperboard products, the biggest export markets were Canada ($2.1 billion), European Union ($1.7 billion), and Mexico ($1.4 billion).

Developing countries (e.g., Chile, Indonesia, and South Africa) are now setting the pace as low cost producers of pulp and some paper products; this is due to their low cost of labor and wood, and subsidies from their governments. Other lesser developed countries with abundant wood resources will likely join these challengers. Also Canada and the Scandinavian countries have traditionally been strong competitors in the forest products industry. Because of the high dependence of their national economies on forest products, they will undoubtedly continue to press the U.S. producers with high quality, low cost products, and technological developments.

In the 60's, the U.S. was the clear technical leader in pulp and paper science, processes and equipment manufacture. However, in the 90's the Scandinavian countries and Canada have taken the lead in many areas, presenting a challenge in the next decade to regain the U.S. leadership position.

The tremendous capital investment required during the 1980s to build and maintain the industry's global competitiveness, coupled with increasingly large environmental expenditures, has taken a heavy toll on industry cash flow, and increased debt to historically high levels. The prospect of additional scarce industry capital being invested to meet marginally beneficial but costly environmental requirements further threatens the industry's global competitiveness.

4. THE VISION FOR THE FUTURE

A. Forest, Wood and Paper Industry Overview

The U.S. forest, wood, and paper industry in 2020 will be the clear global leader in providing safe and essential products in harmony with the environment and will be a sustainable contributor to our nation's economy and to the quality of life of its citizens.

Issues related to **sustainability** and to **energy performance** will play a much more prominent role than today. Expanding global population and development will create much greater demands for energy, resulting in heightened recognition of the need for greater **energy conservation**. Raw materials for both durable and non-durable products will be evaluated based on **sustainability analyses**.

Construction materials, increasingly in demand to meet growing world-wide development, will be evaluated and specified for use based on their own energy demands in production and energy conservation performance when in place. Wood-based products will be preferred over other materials because of low embodied energy and wood's renewability as a raw material. The nature of forest resources with respect to watershed stabilization, ground water quality, habitat diversity, soil conservation, and atmospheric carbon dioxide balance help place all products derived from wood in a favored position.

There will be an increased awareness of the total impact of the industry from **sustainable silviculture** to final product disposal. Process changes will continue to be evaluated from a life cycle perspective to ensure an understanding of the total impact of recommended changes. Increasingly, the industry will come to be viewed as fundamentally in harmony with the environment by managing renewable resources to provide useful products, as well as energy, for society. The use of recovered materials not suitable for product use will also be an accepted energy source for conversion in clean waste-to-energy facilities. Recovered materials will be viewed as a resource and effective systems will be in place to minimize material flows to landfills.

Enhanced financial performance nurtured by **improved capital effectiveness** and a broader range of products will make the industry less cyclical and more viable long term. This will allow smaller increments of capacity to be brought on line in response to demand and give the industry more flexibility in installing new technology.

Recycling of wood and paper products will play a much more prominent role as cost-effective collection and processing technologies are developed. Source identification and enhancement, collection, and reuse will heighten the recovery rate, increasing the industry's product content of once lost recyclable fibers and wood residuals. This will result in an increase in the available resource to meet the greater demand for wood products. Under-utilized species will become an important source of raw materials as technology is developed to improve harvesting and produce economical products from them.

B. Forest Resources

By 2020 there will be an increased awareness of the potential for optimizing the substantial forested land assets of the industry as well as strengthened partnerships between industry, government and other private land owners. Recognition for responsible stewardship of public and private lands will have been achieved which integrates the growing, nurturing and harvesting of trees for useful products with the conservation of soil, air and water quality, wildlife and fish habitat and aesthetics. Biomass will be used not only for building materials and paper and paperboard products, but also increasingly for steam, power, and liquid fuel production.

Although trees as a fiber resource are expected to continue to dominate, recycled fiber will be a larger proportion of the raw material supply than today. Residuals from forests, mills, and converting plants as well as non-recyclable recovered paper, and possibly wood grown specifically as fuel, will provide an important renewable fuel resource.

Wood grown as a raw material for the forest products industry is expected to receive major attention over the next several decades. **Genetic technology** and **other forest science advances** (e.g., gene identification and modification) are expected to enable the growing and harvesting of substantially increased quantities of wood from available land resources, potentially more than doubling current yields per acre. With proper research, domestic supplies will be enhanced through a combination of improved genetic selection, bio-engineering, use of marginal agricultural lands for tree production, and forest management. These developments will ensure that the industry remains competitive with other low-cost producing regions of the world.

New technology and practices will have substantially reduced the current impact of **harvesting methods** on forested lands while reducing costs of moving the industry's raw material from the standing tree to its manufacturing facilities.

Based on better understanding of the **properties of wood** and its components and how to use them most efficiently (including an update of the Committee on Renewable Resources for Industrial Materials–CORRIM–report), a plethora of new and improved wood-based products will be developed. While the competition from other technologies such as electronic communications and a possible trend towards lower per capita consumption of forest based products in developed countries may have tended to reduce wood products usage, growth in lesser developed areas and the advantages of renewability and sustainability compared to other materials are expected to increase the total demand for forest, wood, and paper products.

C. Wood Products

Wood products will be valued for their contribution to the nation's livelihood and well-being. Because they are economical and made from a sustainable resource, they will have a favored position relative to products made from non-renewable raw materials. New products and processes for producing them will be strikingly evident compared to the 1990's.

Processing techniques for wood products will be compatible with the range of available resources, including genetically improved strains, and will be used to produce high value products. Log sorting will be done with nondestructive evaluation techniques for optimum use in end products with closely controlled properties. Automated processing systems will have been developed to accurately locate high value material and optimize the yield for structural products. Perhaps most importantly, new wood products, unlike those currently available, will be manufactured to meet a changing marketplace. Building design will emphasize a systems approach, rather than specification of individual building elements. This evolution will favor the flexibility of wood-fiber based products. New products will have high built-in levels of reliability allowing their substitution in uses not presently permitted. Wood-based products will be combined with other materials to produce "advanced material" composite products that have optimized characteristics, taking advantage of the best features of the combined materials. Treatment technologies will increase wood product service life.

The view for the future includes development of high technology processes with highly automated equipment operated by skilled and trained workers in safe and comfortable environments. Education and training of operators, as well as scientists and engineers, will be of increasing importance.

D. Pulp and Paper

Because of their utility, functionality and attractiveness as well as the recognized sustainability of the raw material supply, new and improved pulp and paper products will continue to be widely used in our society.The major virgin raw material for paper will still be wood. Recovered fiber will have a much greater role than it does today–achieving 50% recovery, of which the majority will be used as raw material going into finished products. Alternative plant fiber will be increasingly viewed as a component of fiber supply but will remain small overall.

A refined and improved collection system for recyclable fibers will develop with public education, community, government, and business initiatives and support. This growth of supply will permit the continued increase of recycled content in products of the future and allow for maximum effectiveness of material recovery and solid waste management programs.

Wood pulping will continue to be dominated by chemical processes, but there will be an increasing improvement in the environmental compatibility of pulping and bleaching operations. In accomplishing these changes, a reduction in the **capital cost** of new pulping facilities and equipment will also have been achieved. The dominant pulping technology is still expected to be the kraft chemical process, but there will be a trend toward increased use of processes that do not utilize reduced sulfur compounds. The chemical recovery of black liquor from the kraft process is anticipated to progress toward

gasification technologies and other processes that have the potential for more optimized cogeneration of the required process electricity and steam. It is also anticipated that these technologies will lower the high capital cost currently associated with the recovery process. The Tomlinson recovery furnace will still be in use, but will be phased out as new facilities come on line and new technologies are introduced. However, advances in design and control will make the Tomlinson units safer and more efficient, and will further improve environmental compatibility. New bleach plants will result in **improved environmental compatibility** through the use of technologies such as reduced water usage, extended use of oxygen based chemicals, and other alternatives. Many of the limitations of mechanical pulping processes (high energy intensity, discoloration with age and reduced strength properties) may be resolved allowing for a greater fraction of paper products to be produced from these high-yield pulps.

It is expected that papermaking processes will also be less capital intensive and will require less energy and fresh water supply. One of the more capital and energy intensive operations in the papermaking process is water removal. Advances are anticipated in the **forming, pressing, and drying** of pulp slurries which will result in improved quality, reduced capital costs, and reduced energy intensity. Paper products will be manufactured to meet ever more stringent consumer quality requirements, and new products will be introduced more quickly to satisfy changing consumer needs. Advanced **process sensors,** computer control systems, expert systems, and mill information systems will continue to be developed and implemented throughout the mill to aid in meeting the product quality requirements as well as to assist in the efficient operation of the manufacturing plant. **Computer-based control systems** will extend into the distribution and logistics networks to reduce inventories and shorten product delivery cycles.

Improved understanding of the **fundamental chemical and physical properties of fibers**, fiber structures and their interaction with other materials applied in or after the papermaking process will assist in designing better products. New products, whether those made from paper alone or in combination with other materials, will be more functional while using less energy and materials.

Energy consumption per unit of product output will be lower; however, electricity will be an increasingly important fraction of the energy used. **Biomass and black liquor gasification** will play an increasingly important role as components of advanced cogeneration technologies. These technologies will be incorporated to optimize the generation of electricity and process heat. Compliance with air regulations will necessitate effective combustion control and accurate continuous monitoring. There will be a trend toward closing the remaining open water cycles in mills and the goal for all mills will be to continue to **reduce water consumption.**

The capital cost of facility rebuilds and expansions as well as new construction will be reduced out of necessity. Technologies involving new processes, **new materials of construction** and **new construction techniques** will be employed to lower forest, wood, and paper industry capital intensity, bringing it closer to the all-industry average.

With the continual tightening of pulp and papermaking processes will come the need for improved or alternative materials of construction or ways to handle the changing chemistry of the process. To ensure safe operating systems with high levels of integrity, corrosion and materials management must be well understood.

As with the wood products segment of the industry, the future includes the development of high technology processes with highly automated, modern equipment which is operated by skilled and trained workers in safe and comfortable environments. Thus, education and training of operators as well as scientists and engineers will be imperative.

5. TECHNOLOGY SUMMARY

In comparing the forest, wood and paper industry's vision of the future with today's situation, several important strategic issues emerge which drive the proposed technology program to:

- become more competitive with developing countries in wood and fiber production;
- anticipate and understand public expectations associated with its woodlands and manufacturing operations;
- establish a position of increased energy efficiency;
- improve capital effectiveness;
- enable the collection and use of materials generated by non-traditional sources of recovered fiber;
- increase product flexibility and reduce cycle time for new product introduction; and
- maintain leading-edge, low-cost manufacturing facilities for producing high quality products.

6. RESEARCH PRIORITIES

AF&PA, supported by NCASI, RPTA, FPS and TAPPI, has made a concerted effort to develop a long range research agenda for the industry. This effort has involved representatives from the pulp, paper, packaging, recycling, forestry and wood products segments of the industry. It is the intent of this research agenda to set a direction for the entire industry as opposed to any single segment or company. This is consistent with the primary goal of improving the global competitiveness of the industry as a whole. Further, the agenda as presented here, focuses on raw material, environmental, energy and process areas and not on product research areas which are deemed to be more appropriately carried out by individual companies as they see fit. However, the agenda does emphasize an improved understanding of the fundamental science and technology, such that individual company product and process developers can use the anticipated research results to help their company's products not only excel in performance against other materials, but also to maintain healthy intra-industry competition.

Importantly, the implementation of this agenda must be a cooperative effort between government funding agencies that can help accelerate the needed research results and technology commercialization, the research institutions that support the industry, suppliers to the industry, and the industry itself. To this end, the supporting institutions have been involved in the development of this document. Government agencies will find its contents useful in considering policy affecting the industry and in making funding decisions.

The analysis undertaken has led to several high priority areas for research, development, and commercialization. These are summarized below.

A. Sustainable Forest Management

The industry needs to continue its practice of sustainable forestry which integrates the production of wood and paper products with other environmental values including the conservation of soil, air and water quality, wildlife and fish habitat, and aesthetics. On industry's most productive sites, growth rates must increase and fiber quality will need to be substantially enhanced (perhaps 2-4 times current growth rates) to continuously improve the industry's competitive advantage in wood production, harvest and delivery to world markets. Forested areas on marginal agricultural lands will be increased and will need specific attention.

In 1993, AF&PA published a detailed national report outlining the Industry's Suggested Forestry Research Priorities for the 1990's. In addition, the National Research Council of the National Academy of Sciences published a report: *Forestry Research, A Mandate for Change* to serve as a vision for future forestry research.

Common areas of high priority research include:

- *Sustainable Forestry* – Develop systems and methods to sustain the productivity of intensively managed forests for present as well as future generations, including attention to biodiversity.
- *Selection and Hybridization* – Develop optimum natural species and hybrids for use in local conditions.
- *Genetic Engineering and Tree Breeding* – Modification of gene structure and incorporation in improved tree breeding and genetic selection programs to increase growth rates, improve insect and disease resistance, improve fiber quality, and enhance environmental adaptability.
- *Forest Management and Productivity* – Develop and implement management techniques to maximize fiber yields at low cost and to minimize ecological impact, including conservation of certain unique ecosystems.
- *Raw Material Properties* – Given the shift towards a greater reliance on younger, faster grown material, a concentrated effort is needed in the areas of: 1) tree physiology, plant genetics, and the integration of genetics with silviculture to achieve fast-growing, disease-resistant, good form trees that produce high quality wood; and 2) fundamental information that will allow the use of short rotation trees and mixtures of traditional and non-traditional species in a wide range of solid and composite wood products and as a wood pulp raw material.
- *Harvesting* – Develop low-cost and energy-efficient harvesting techniques that have low impact on the productivity of soils and allow for selective cutting.
- *Soils* – Enhance the level of knowledge and develop approaches to protect the basic productivity of soils.
- *Diversity* – Develop methods to ensure adequate preservation of gene pools and local diversity of species.

- *Forest Inventory* – Improve information collection regarding quantity and quality of timber, age class distributions, and the effects of expanding markets on overall supply.
- *Water Quality* – Identify compatible forest practices with other wetland functions, water quality and quantity and beneficial uses of riparian areas.
- *Ecosystem and Landscape Planning* – Develop models and other analytical tools for assessing effects of various landscape patterns and how forestry can help maintain resource values over time and space.

B. Environmental Performance

The industry must continue to assure that manufacturing facilities are worker and community acceptable. Research on understanding the effects of potential discharges should receive priority. Some specific areas for continued and future consideration include:

- *Human and Environmental Effects* – Study effects of manufacturing process discharges on humans and the environment.
- *Energy and Environmental Trade-offs* – Recognize, before broad implementation, the environmental and energy impacts of technology changes directed at improving environmental performance.
- *Improved Wood Products Adhesives* – As new products are developed, the use of adhesives will increase. Research is needed to ensure they are durable, low-cost, and produce no toxic side effects on workers and users.
- *New Treatments for Durability of Wood Products* –The service life of wood in exposed environments can be extended significantly by designs and treatments to control fire, decay, mold, insect infestation, etc. Concerns have been raised with current treatments about the environment, human safety, recyclability and disposability. Research to develop benign treatments that can enhance the durability of wood products and improve dimensional stability is needed.
- *Reduction of the Impacts of Liquid Effluent* – Develop technology for enabling wood products, pulp and paper mills to operate in harmony with the environment.
- *Reduction of the Impacts of Gaseous Discharges* – Develop low odor pulping, efficient capture and treatment of gases, and low emission process technologies for the manufacture of wood, pulp, paper and recycled products.
- *Solid Wastes* – Develop waste minimization, recycling, and energy recovery strategies and technology.
- *Removal of Non-Process Elements in Pulp and Paper Operations* – Develop low cost, energy efficient separation technologies to remove contaminants, and treatment technologies to clean remaining discharges.

C. Energy Performance

To be economically competitive, the industry must be able to utilize the lowest cost fuel at all times and capitalize on emerging low cost technologies. Where economics are favorable, it is possible for many operations within the industry to become essentially independent of fossil fuels, meeting their internal needs with self-generated, renewable fuel from what are now waste streams. In addition, as the nation's demand for electricity and renewable liquid fuels increases, the industry can be an effective partner with utilities, chemical, and oil companies in helping achieve renewable energy goals. To accomplish these goals, energy utilization and production technologies must be improved as well as the development of new techniques to extract maximum energy from the waste streams. A partial list of areas needing attention are:

- *Energy Conservation* – Studies in this area should include methods of low level heat recovery.
- *"Life Cycle Assessment" of Materials and Systems* – Forest, wood and paper products need to be carefully evaluated relative to their energy efficiency in production and use compared to other materials.
- *Energy Efficiency in Wood and Paper Drying* – Wood drying is the largest energy requirement in the production of wood products. Improved understanding of the fundamental relationships between drying efficiency and product quality and uniformity is needed for both wood and paper products.
- *Combined Cycle, Cogeneration* – This area should address the goal of extracting maximum usable energy from biomass, waste and fossil fuels and the development of productive uses for the non-combustible products.
- *Biomass and Black Liquor Gasification* – These technologies should be commercialized to allow improvement in efficiency and reduction of capital intensity.
- *Non-Recycled Wood and Paper to Energy* – Develop collection and conversion technologies to take maximum advantage of the high value wood and fiber components diverting the remaining residuals to energy production in an environmentally acceptable manner.
- *Wood Based Chemicals* – Opportunities for process integration allowing the production of chemicals should be continuously evaluated as new technologies are developed and competing economics change.

D. Improved Capital Effectiveness

Reducing capital requirements per unit of production and sales will enhance financial performance and make the industry more viable by allowing smaller increments of capacity to be brought on-line in response to demand and by giving the industry more flexibility in installing new technology. All R&D areas should address the capital intensity issue as well as their primary objectives.

- *Kraft Chemical Recovery Process* – Develop lower cost, safer and more efficient alternatives to the existing processes. Black liquor gasification has significant potential.

- *Water Removal* – Develop lower cost, more energy efficient forming, pressing and drying technologies for paper and wood products.
- *Construction Methods* – Develop methods for constructing large and small facilities at lower cost.
- *Materials for Fabrication* – Develop new materials for the industry's processing equipment which are cheaper to use, less expensive to maintain, and stand up to the harsh nature of the many chemical process technologies utilized. All through the pulp and papermaking process (e.g., recovery furnaces, bleach plants, paper machines, chemical preparation and storage) better materials are needed to withstand the severe heat, physical, and chemical environments. Also, more rugged and durable materials are needed for the construction of harvesting and log processing equipment, which is subject to extreme mechanical stress.

E. Recycling

Recycling broadens the raw material base of both the wood and paper products industries. Enhanced development of the "urban forests" will continue to be investigated by organizations such as RPTA, who work with equipment manufacturers and the industry to achieve favorable separation and recovery of fibers. Once separated, these fibers can be successfully incorporated in a wide variety of pulp, paper and other products. Optimal combination of the virgin and recycled pulps is highly complex and should receive attention. R&D aimed at lower cost, reducing energy usage and fiber deterioration in recycling is key to significantly expanding the use of recycled products. Some additional specific areas for research, development and commercialization are:

- *Collection Systems* – Innovative collection techniques, systems and equipment are needed to significantly improve the acceptance and economics of moving more recovered materials into products that require increasing performance and quality.
- *Separation Technologies* – New cleaning system technologies are needed to allow for more specific separations between desirable recycled components and unacceptable contaminants, thereby increasing the amount of recycled fiber useable in marketable products.
- *Fundamental Understanding of Fiber-Fiber Bonding* – Improved product strength together with increased recycled fiber use can be achieved by a better under standing of fiber surface chemistry.
- *New Technologies for Sludge Use and Disposal* – Emphasis here should be on methods to allow deinking plants to operate in a more environmentally acceptable and economic manner.
- *Methodologies and Tools* – Techniques are needed to allow the establishment of valid statistical characterization of incoming recycled fiber raw material streams.
- *Concepts and Technologies for Wood Recycling* – Systems for wood recycling need to be developed that are cost efficient and environmentally acceptable. Development of such systems needs to include recycle capabilities for much of the construction and demolition waste currently going to landfills, as well as composite materials containing varying resins and chemical treatments.

F. Sensors and Control

- *Process Measurements and Controls* – The complexity of processes and the need for maximum efficiency and low cost require the need for ever-increasingly sophisticated real-time measurement and control systems. Some specific areas for consideration:
    - *Environmental-related Sensors*, internal and external
    - *Process-related Sensors*
    - *Product Quality Sensors*
    - *Large System Controls* to optimize and control entire mills or larger systems
    - *Expert Systems*
- *Wood, Fiber and Paper Products Characteristics* – Knowing more about the fundamentals of structural, optical and other performance attributes will lead to higher product performance which can either reduce the amount of material needed to obtain necessary performance or allow design of unique qualities into products so they can compete more favorably with other materials.
- *Computer-based Models of Wood Characteristics and Structural Performance* – Development of cost-saving computer-based models are needed that can demonstrate the structural and fire performance characteristics of wood products and systems, enhance innovation in design, reduce costly destructive testing, and provide confirmation of acceptable performance.

7. CLOSING COMMENTS AND NEXT STEPS

The U.S. forest, wood and paper industry has been very successful in maintaining a low cost, high performance position in the global arena over a number of decades. However, it is rapidly being challenged not only by the traditional competitors (Canada, Scandinavia, Japan) but also by some aggressive emerging nations (Brazil, Chile, Indonesia). Other third-world countries with abundant wood resources are expected to enter the global picture within the next 10–12 years. The U.S. forest, wood and paper industry and its stake holders cannot allow this new era of global competition to diminish in any way the industry's future success and growth opportunity. The jobs, exports, infrastructure, assets and opportunity for the creation of wealth that the industry represents must be protected and nurtured. Because of significant demands for capital to meet mandated environmental objectives, industry's research and development investments do not fully address the longer-term needs of the industry. U.S. wood products, pulp and paper companies are currently not spending enough on R&D to remain competitive over the long term against other industries or against European and Scandinavian manufacturers. Thus, the industry welcomes initiatives to strengthen the partnership between government agencies (e.g. the DOE, USDA, Department of Commerce) and industry to ensure that this prominent sector of our economy continues and expands as a viable industry in this country. With early attention to the high priority needs described above, this important industry will continue to maintain its competitive advantage in the global market place.

Following approval of this technology vision and research agenda by the AF&PA Board of Directors, an implementation plan will be developed in partnership with DOE and other interested government agencies, a team of CEO's, Technology Officers, and other appropriate individuals. The plan should include, but not necessarily be limited to:

- an operating structure;
- a framework for partnership; and
- a blueprint for the implementation program and evaluation of results.

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University of Washington – Pulp and Paper Science and Chemical Engineering

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Virginia Polytechnic Institute – Department of Wood Science and Forest Products

Western Michigan University

Agenda 2020

A Compact for the Forest Products Industry

The Forest Products Program is a voluntary collaborative effort between the forest products industry and the U.S. Department of Energy. The purpose of the Compact covering Forest, Wood, Pulp and Paper is to provide the framework for identification of appropriate areas for joint research, development and technology demonstration. The result will be a research partnership between the Department of Energy and industry.

This collaboration implements and will go beyond the provisions of the Energy Policy Act of 1992, concerning a five-year research program for the pulp and paper industry. Moreover, it is consistent with the Climate Change Action Plan and is expected to make a contribution to reducing greenhouse gases.

The outcome from the research partnership will be the demonstration, evaluation and acceleration of new technologies and scientific insights that address several cross-cutting national needs:

- ◆ To advance the global competitiveness of the forest products industry by building technological leadership in the face of substantially increased research & development subsidies in major competitor nations in recent decades.
- ◆ To continue improving the sustained management of the forest resource, recognizing its multiple uses and its essential position as an available, stable, low-cost raw material base to the industry.
- ◆ To be capable of meeting demanding environmental requirements without the predicted increases in capital expenditures, operating costs and energy consumption.
- ◆ To continue the significant progress in building energy self-sufficiency and to take full advantage of available by-product biomass as a fuel source.
- ◆ To increase further the economic stability and use of recycled wood and paper materials.

These are the critical long-range needs that must be met in order to take continuing advantage of the unique benefits of wood-based products exemplified by their low embodied energy and renewability as a raw material. These inherent benefits stem from the nature of the forest resource–the multiple uses for the eco-system resource including watershed stabilization, ground water quality, habitat diversity, soil conservation and contributions to the atmospheric carbon dioxide balance.

The work that springs from the research partnership will be carried out in a joint federal-industry program designed to develop technologies for the use of industrial end-users. It will be guided by collaboration among: industry, associations, agencies of the federal government, universities and other major research institutions with expertise in the fields of interest.

The program will be structured into six operating task areas: 1. Sustainable forest management, 2. Environmental performance, 3. Energy performance, 4. Improved capital effectiveness, 5. Recycling, and 6. Sensors and control.

Each of these areas is relevant to all industry segments–forestry, wood products, and pulp and paper products. The research agenda will also cover a spectrum of technology maturities, from basic research to development and demonstration projects.

This agenda will address projects that benefit the industry broadly rather than specific product research and development work. Although product development is essential to the long term success of the industry, it is a primary basis for competition among companies and is best left to the individual efforts of company research and development programs. However, studies of the fundamental chemical and physical characteristics of fibers and fiber structures will be addressed.

The Forest Products Program is also intended to re-emphasize and support the activities already underway in collaborative activities involving the government, industry and academic institutions. Examples include: advanced water removal and drying systems for paper production; black liquor gasification; fluid dynamic modelling of recovery boilers to characterize effective and efficient combustion; development of high performance wood products using less materials; development of computer models to characterize accurately wood product performance; genetic tree improvement; forest ecosystem management; comprehensive watershed studies; and integrated pest management.

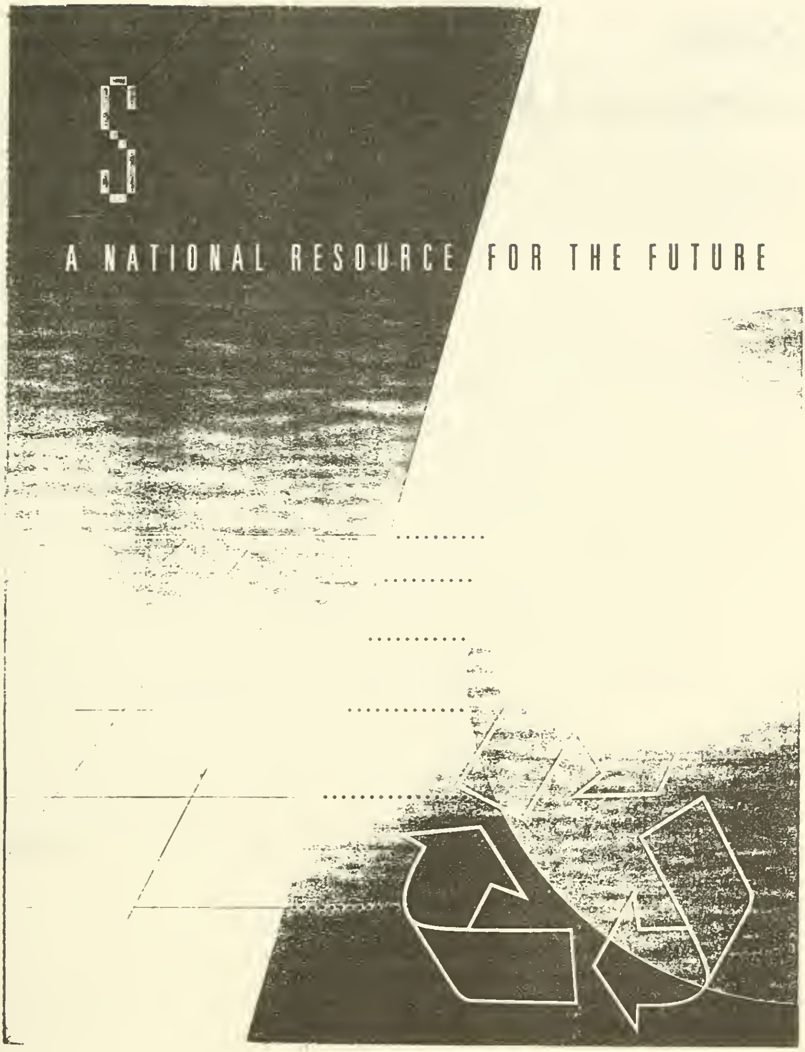
This Compact expresses the intentions of the parties to pursue a collaborative research effort. It does not, however, create legal rights or obligations for either party and either party may withdraw without penalty and without being subject to remedies at law or equity.

This compact shall become effective upon execution by representatives of the United States Department of Energy and of the American Forest & Paper Association for the industry. It shall remain in effect for two years, but may be extended by mutual agreement of the parties.

Signed on the 22nd of November, 1994:

Hazel O'Leary, Secretary
United States Department of Energy

Robert C. Williams, Chair
American Forest & Paper Association's
Chief Executive Officer Working Group
for the research agenda implementation



A NATIONAL RESOURCE FOR THE FUTURE

Steel

A National Resource for the Future

May 1995

ACKNOWLEDGEMENTS

The volume of material available, and the analysis that has been done, with respect to the steel industry is significant. For those readers requiring detailed information, authoritative descriptions of the industry are available together with several reports which reflect various aspects of the industry's technical vision. Some of the information and ideas offered in this report have been gleaned from these sources, which are described and referenced in the Appendix. The report by Professor Fruehan and his co-workers (reference #7) was especially valuable.

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STEEL: A NATIONAL RESOURCE FOR THE FUTURE

EXECUTIVE SUMMARY

This document provides an assessment of the current state of the American steel industry, and a vision for the future of the industry. In making this assessment, the recent history of the industry is examined, particularly the major factors that have influenced change in the industry in recent years, as well as ongoing industry efforts to address competitive challenges.

Other industrial sectors have only recently initiated coordinated efforts to assess future technological challenges and needs. This is not the case for steel In addressing competitive challenges, the steel industry has historically undertaken significant collaborative efforts in research and development, and in developing common objectives for the future of the industry.

The American steel industry is committed to making steel the material of choice for the 21st century. The knowledge and experience gained from addressing recent competitive and technological challenges point the way for the continued improvements that will be necessary for the industry's long-term success This paper presents a vision for the future of the American steel industry, and identifies technological and other issues that must be addressed to accomplish this vision

STEEL: A NATIONAL RESOURCE

The American steel industry today is among the most productive, efficient and technologically sophisticated in the world. and remains vital to economic competitiveness and national security The industry employs 170,000 Americans, in jobs paying 50 percent more than the average for all manufacturing.

Steel is present in the lives of all Americans. It is present in the home in appliances, tools and household equipment, as well as in the walls of the house itself, and is the basic material in the family car Steel is the most widely used engineering material in manufacturing, and forms the backbone of the infrastructure that defines our society, from silos to sky-scrapers, from railroads to highway bridges, and from pipelines to supertankers.

Steel is the material of choice for all these applications because of its basic attributes: it offers unique combinations of strength and ductility which can be transformed and worked to give the customer an almost infinite variety of product properties, at an extraordinary value. Although the production of steel involves sophisticated equipment costing hundreds of millions of dollars, the final product is delivered more cheaply per pound than potatoes dug straight from the earth.

The combination of low cost and attractive engineering properties assures steel a continued vital role in the future materials marketplace.

Steel is also the most recycled of all materials. The steel industry recycles nearly 55 million tons of scrap annually, producing more than 50 percent of all steel from recycled material. During the last decade, more than two and a half tons of steel scrap were recycled for every American. Each year, two billion dollars of savings in waste disposal costs are achieved by recycling scrap steel.

Despite the appeal of this versatile material, the steel industry has confronted significant competitive challenges which forced major restructuring within the industry. These forces dramatically altered the shape of the industry and resulted in its renewed economic strength and vitality. Notwithstanding this success, the American steel industry will continue to face significant competitive challenges in the years to come.

COMPETITIVE PRESSURES FACING THE STEEL INDUSTRY

In the last twenty years, a number of significant economic and technological factors have combined to influence the changing structure of the steel industry in America. These factors included worldwide overcapacity; extreme overvaluation of the dollar; increases in the cost of energy; increased environmental and safety regulations; the rise of competing materials; technological changes; the cost and availability of capital; and demands of customers for higher quality products.

These factors will continue to play a role in shaping the future of the steel industry. While the American steel industry has eliminated excess capacity, lower capital costs for new facilities has capacity on the rise, and worldwide capacity continues to exceed demand, even in peak years. Rising production and competition from new, emerging economies will add to the pressure from international competition and imports.

Likewise, the American public will continue to demand that industry contribute not only to the economic health of the community, but to the environmental health as well. The steel industry will face pressure to further improve performance in air and water emissions, reduce waste products, and increase energy efficiency

Increased pressures to reduce solid wastes will provide an incentive for the industry to expand the use of scrap, and heighten the benefits of steel as the most recycled material. However, tightened environmental standards will also provide opportunities for competing materials, particularly in the automotive industry which faces demands to produce vehicles which achieve significantly greater fuel-efficiency without compromising consumer expectations for utility, safety, performance and affordability.

The steel industry will also be influenced by sweeping changes in manufacturing philosophies. Gone are the days of one-size-fits-all manufacturing with its concurrent indifference toward customers and consumer expectations. In its place are modern manufacturing systems, characterized by just-in-time production, demanding product specifications, exacting quality demands, specialized manufacturing, and flexible systems. In this environment, continuous improvement must be the guiding principle and quality and productivity improvement the way of life. Closer coordination with customers in the design and integration of steel into the final product will be required. Flexible steelmaking will require the development and application of better process controls and sensors. Increased technological sophistication in the production of steel will also require a more highly skilled, flexible workforce with direct input into production decisions, the ability to identify and analyze problems, and the authority to implement solutions.

Underlying all these currents will be the steady demand for capital. The production of steel will continue to be highly capital intensive. The availability of and access to capital will remain significant issues for the steel industry. New capital investment must be made wisely and effectively, targeting new technologies and optimizing technological advances in the most productive, efficient facilities.

The American steel industry is dynamic and evolving. Established traditions have given way to new standards and practices. The industry has embraced constant improvement and advancement as the keys to long-term competitiveness. With its experience, strength and renewed vitality, the industry expects to meet and exceed the challenges of the future.

A VISION FOR THE STEEL INDUSTRY OF THE FUTURE

Steel will remain the material of choice for manufacturing in the 21st century. The American steel industry of the future will be a strong and vibrant sector of the economy, providing high quality, value-added products to a wide array of customers in an environmentally-friendly, cost-effective manner. The American steel industry will remain the low-cost producer for the U.S. market. It will continue to be globally competitive on cost and quality, and will lead the world in innovation and technology.

Recycling will play a larger role in the industry. Steel production from recycled material will increase largely from the greater use of plant waste materials. Better collection systems and public awareness will contribute to steel's value as a material. Greater attention to life cycle analysis and an understanding of the total environmental impact of products will increase steel's value versus other materials, including wood, other metals, and composite materials.

Future production of steel will be more energy efficient and environmentally-friendly. Processes will be more closed and continuous and will be more flexible in energy sources. Emphasis will be given to new technologies which improve productivity, reduce capital intensity and limit or eliminate the generation of waste.

The industry will be characterized by greater manufacturing flexibility. No single process arrangement will be preferred for steel production; rather, processes will be tailored to match specific market and customer needs. Technologically sophisticated process controls and sensors will further improve productivity, quality and product properties. Producers will have better ability to predict, monitor and control product properties on-line, and will work closely with customers in product design, application and recycling.

Close relations with customers and suppliers will typify the industry, which will rely on an increasingly highly skilled and flexible workforce. Better understanding of steel's properties will enable customers to improve product engineering and design to achieve higher performance and value.

The industry will be profitable and attractive to investors It will contribute high-value products and high-skilled jobs to a healthy and growing manufacturing economy.

RESEARCH OPPORTUNITIES AND TECHNOLOGY DEVELOPMENT

To retain steel's position as the material of choice for the 21st century, continuous improvement will be required in four critical areas:

- production efficiency;
- recycling,
- environmental engineering, and
- product development

The steel industry has ongoing efforts in each of these areas with both short-term and long-term potential. These efforts must continue and build upon the success of the past. Continued international competition will require the industry to collaborate on significant technological challenges and draw support from a wide range of sources including government, academia, and other industry partners.

COLLABORATION FOR THE FUTURE

In the past, the American steel industry has engaged in successful collaborative projects with government, academia, suppliers and customers to address technological needs. Such efforts helped offset the impact of decreased research capabilities at the individual company level, and demonstrated the competitive advantages that accrue to the industry and participants.

As the U.S. continues to face increased international competition, it will become increasingly important to better utilize R&D resources through a broad range of collaborative activities. Individual companies will find it increasingly difficult to obtain sustainable competitive advantage. In a global marketplace, the U S steel industry must strive to maintain its competitive position through collaboration. Such efforts will leverage the resources and research capabilities of individual companies, provide a closer link between private and public research, and ultimately insure a greater return to society on these investments Successful collaboration on the technological issues identified in this report will maintain the strength and vitality of an important manufacturing sector

STEEL: A NATIONAL RESOURCE FOR THE FUTURE

THE AMERICAN STEEL INDUSTRY

The American steel industry today is among the most productive, efficient and technologically advanced in the world, and remains vital to economic competitiveness and national security. The industry employs 170,000 Americans, in jobs paying 50 percent more than the average for all manufacturing.

In 1994, the steel industry had sales of $50 billion on domestic shipments of 95 million tons, accounting for a full 0.7 percent of the U.S. economy. This past year also saw a return to profitability for the industry.

That the American steel industry is flourishing speaks to the fact that steel remains the material of choice for manufacturing, providing unique combinations of strength and formability at an exceptional value. Steel's success is also a measure of the resolve of industry managers to respond to the competitive challenges facing the industry. To this end, the steel industry has:

- Reduced overall energy consumption by domestic steel firms by 43 percent in the last 20 years;
- Increased productivity 94 percent since 1980 in terms of output per employee-hour;
- Invested more than $6 billion on environmental control equipment in the last twenty years, resulting in the removal of more than 95 percent of the air and water pollutants associated with operations;
- Led all industries in recycling, producing more than 50 percent of all steel from recycled materials and annually recycling nearly 55 million tons of scrap;
- Focused on market demands and the development of steel-based solutions.

Today's American steel industry is globally competitive, environmentally responsible and energy conscious. Despite recent success, the industry will continue to face significant economic and technological challenges to remain competitive. The steel industry has demonstrated the success of collaborative efforts between the government, industry, academia, suppliers and customers. Many of the issues confronting the industry today and in the future will demand policies to encourage collaboration and support innovation.

This paper presents a vision for the future of the steel industry and the technological and competitive challenges inherent in this vision. The paper is intended to provide a basis for continuing collaboration within the industry and with other partners to ensure steel remains the material of choice for the 21st century.

HISTORY OF THE AMERICAN STEEL INDUSTRY

No vision of the future of the American steel industry can be written without first looking back to consider the history that defines both the reality and the enduring popular notions of this quintessentially American industry. This is particularly true for steel, where progress in recent years has outpaced public perceptions of an industry which remains vital to economic competitiveness and national security.

The early history of the steel industry was truly the story of America. personalities larger than life seized the opportunity of a rich, exploding continent and forged a country and industry populated with powerful companies and dominant individuals. The industry was fueled by American industrialization and rich natural resources, providing an indispensable commodity for the growing nation

This popular notion of steel as the bedrock of the nation's industrial strength was reinforced by the role the industry played in the successful U.S effort in World War II and the dominance of the American industry following the war The American steel industry not only survived World War II, but emerged as the only producer capable of responding to the massive world demand associated with efforts to rebuild in Europe and Asia.

By the 1980's, however, a combination of factors had seriously undermined the foundations of the industry. Imported steel, driven by world overcapacity and produced with newer facilities and technology had eroded the U.S. industry's competitive position Political and economic interests in Europe and Asia assigned importance to healthy domestic industries and contributed to the build-up of excess capacity. These same political interests also encouraged predatory and unfair practices to sell in the American market. At the same time, domestic economic policies to contain inflation in the late 1970's and early 1980's caused a dramatic increase in the value of the dollar, at times giving imported steel an enormous price advantage to the detriment of the American steel industry

At the same time, domestic public policies to protect the environment and improve the health of workers added new costs and created new technological hurdles for the industry. Beginning in the 1970s, the United States enacted broad new laws to regulate worker exposure to hazardous materials, the generation and treatment of air and water pollutants, the handling and clean-up of hazardous and toxic wastes, and the disposal of solid wastes and recycling. Each of these concerns is fundamental to the steel industry which is highly resource- and energy-intensive. These new laws went above and beyond significant efforts already underway in the industry to improve environmental performance and forced the industry to invest a significant portion of capital on pollution controls, thereby crowding out investment in improvements to enhance competitiveness, and delaying the application of new technologies.

The energy crisis of the 1970s and subsequent public policies enacted to regulate energy usage also had a negative impact on the industry. The production of steel is highly energy intensive, with energy costs amounting to over 15 percent of the manufacturing cost of steel. The energy crisis raised questions of energy costs and stability generally, and forced the industry to focus on improving efficiency to make costs and supplies more predictable.

In addition to volatile energy costs, new legislation aimed at reducing reliance on foreign energy sources had significant, indirect effects on the industry. The most notable example is the 1975 Energy Policy and Conservation Act. This act introduced the concept of Corporate Average Fuel Economy (CAFE) and established a requirement that the average new car achieve a fuel efficiency of 27.5 miles per gallon. This new requirement resulted in an average weight decrease of 1000 pounds per car. This translated into less sales to auto manufacturers for the industry. It also opened the door to competing materials, particularly aluminum and plastics.

The energy crisis of the 1970s, coupled with the availability of high-quality, low-cost scrap material, also provided an opportunity for new domestic producers to enter the steel market. These new producers -- often referred to as "mini-mills" -- utilized the electric arc furnace (EAF) to melt scrap. This process achieved significantly lower costs for the production of low-end products.

The new EAF producers also achieved greater productivity than integrated producers and were able to drive out some imports. Ultimately, EAF producers began to broaden their product lines into the dominion of the integrated producer. The remarkable success and rise of EAF production changed the shape of the industry, forcing traditional integrated companies to focus on the higher value, higher quality products and on cost and efficiency improvements within their processes. In some cases, production concepts employed by EAF producers have been emulated by integrated producers in order to provide a full range of products in a cost-effective manner.

Cumulatively, these factors changed the dynamic of the American steel industry, and seriously threatened the industry, bankrupting some integrated producers. The industry responded with dramatic restructuring and a resolve to regain competitiveness. This restructuring included collaborative efforts within the industry, and partnerships with government to provide the industry the ability and time to implement reforms.

RESTRUCTURING OF THE 1980'S

The 1980's witnessed a marked determination by the steel industry to regain competitiveness. The industry was bolstered in these efforts by government policies enacted to give the industry relief from unfair international competition while reforms were put into place. As the extent of import penetration and harm was recognized, the U.S. government under the Reagan administration initiated negotiations to restrict the access of foreign steel to U.S. markets. These negotiations resulted in time-limited restrictions on the amount of imports allowed into the U.S. market. Known as Voluntary Restraint Arrangements (VRA's), the restrictions were in force in some form from 1982 to 1992, and gave the American steel industry breathing room in which to improve competitiveness. For its part, the industry responded with aggressive resolve.

During the 1980's, the American steel industry:

- Eliminated obsolete plants on a massive scale and reduced the size of the workforce;
- Increased productivity to the highest of any steel industry in the world;
- Formed strategic alliances with key customers to regain markets lost to competing materials;
- Consolidated resources to target on high-performance material applications;
- Invested in new technologies and upgraded remaining facilities;
- Continuously extended the range of high quality products available from EAF production;
- Focused new attention on quality and customer relations,
- Improved environmental controls and reduced waste products,
- Introduced a variety of new products, including super formable, ultra-low carbon steels, high strength steels with increased ductility, more energy efficient electrical steels, newly engineered coated sheet products, and bearing steels with four-fold improved fatigue resistance,
- Cut energy costs and improved efficiency;
- Advanced the product application technology to improve steel's competitive edge.

The steel industry also turned to collaborative efforts to address competitive challenges. The industry formed proactive partnerships within the industry, and with government, academia, suppliers, customers, employees and other industrial interests to develop the advanced technology that would lead the industry into the next century

COLLABORATIVE EFFORTS BY THE AMERICAN STEEL INDUSTRY

The economic forces which buffeted the steel industry in America also took their toll on the industry's research community. The funding of academic research and the large laboratories that had flourished during the 1960's were prime targets for cuts. Dwindling research capabilities by individual firms created a need for collaborative efforts within the industry.

In the early eighties, the American Iron and Steel Institute (AISI) initiated a project to identify areas meriting serious consideration for the development of process controls and sensors. A 1982 workshop co-sponsored by the National Bureau of Standards (later the National Institute of Standards and Technology or NIST) and the Defense Advanced Research Projects Agency (DARPA) brought scientists and engineers in industry, universities and government together and provided them information on the specific process control sensor needs of the steel industry. Within six months, a preferred proposal had been identified, and partnerships and funding were developed for each of the projects. These projects demonstrated the organizational and synergistic benefits of collaborative research, and attracted significant participation from other industrial sectors.

In addition to collaboration within the industry, steel producers reached out to form partnerships with suppliers and customers A notable example is the Auto-Steel Partnership designed to increase the efficiency with which steel is utilized in manufacturing automobiles. This program has improved relations with customers in this important market for steel and accelerated the implementation of the latest technologies As a result, substantial quality improvements have been achieved More recent efforts have included programs with the food processing industry, appliance manufacturers, and homebuilders

The steel industry also participated in collaborative efforts with the government. In the mid-eighties, a White House report known as the Packard Report recommended increased collaboration between the national laboratories, universities and industry to ensure a better return to the public for federal research investments. This report formed the basis for increased government/industry collaboration

Starting in 1986, the Department of Energy (DOE) and the American Iron and Steel Institute jointly organized a series of workshops to define the technology required to move toward the energy-efficient and environmentally-friendly plant of the future. These workshops drew strength from participation by eminent scientists from academia, the national laboratories and NIST, as well as producers, suppliers and customers.

These workshops resulted in a series of intensive studies designed to lay the technological foundation for the steel industry of the future. The first of these "foundation projects" researched smelting technology to produce the molten iron required for steelmaking directly from domestic coal and iron ore pellets. By eliminating the need for coke and coke ovens, this technology could provide the basis for the environmentally benign plant of the future.

Since March of 1994, the potential of this new technology has been extended by further research to encompass the processing of steel plant wastes to produce molten iron. Rising costs associated with disposal of these wastes provides a significant economic incentive for this process. Immediate plans call for a demonstration plant to operate on a commercial basis, and have attracted collaborative support from four oxygen suppliers and an iron ore producer in addition to steelmakers

The second "foundation project", the AISI/DOE Advanced Process Control Program, comprises a group of projects which will move the industry toward the closely controlled, continuous, energy-efficient plant of the future. Initiated in 1993, this five-year program includes six sensor and control system research projects designed to develop technology to monitor key steps in the production of steel. The ability to determine product properties on-line will allow steelmakers to establish the critical link between process and product and narrow the gap between today's technology and the industry of the future.

This partial list of programs illustrates the scope of collaborative research and development efforts undertaken by the American steel industry. In total, more than $80 million has been invested in such research projects since the 1980's. Through the collaborative process, funding from steel industry participants was matched from a variety of external sources, and leveraged by a factor of 2 or more. The research talents of the industry were equally enriched by the participation of other organizations.

Ultimately, the painful restructuring made during the 1980's reestablished global competitiveness for the American steel industry. The experience gained from this restructuring and from collaborative efforts will provide the foundation on which to build the industry of the future.

THE AMERICAN STEEL INDUSTRY TODAY

The American steel industry has made a remarkable turnaround and is now among the most efficient steel producers in the world. The American steel industry today is highly productive and energy efficient. Over the past decade, steel companies in the United States invested nearly $30 billion in new process and product technologies As a result, labor productivity improved by over 90 percent since 1980, and energy consumption per ton of steel produced decreased by 43 percent since 1975.

The American steel industry today is technologically sophisticated and customer-oriented. New process technologies have dramatically improved the quality of steel and increased yields from around 70 percent in the early 1970's to over 85 percent today. Rejection rates at some automobile plants due to quality concerns have decreased by a factor of ten, and demand for American made steel is currently high.

The steel industry today is a knowledge-based industry increasingly reliant on advanced technologies to produce sophisticated, high value-added products Half of the products sold today could not have been produced ten years ago. The expanded use of advanced technologies, including vacuum degassing, ladle treatments, continuous casting and product coatings, has led to the introduction of new and improved products. For example, ultra-formable steels are utilized for complex automotive parts and energy efficient electrical steels have improved the energy efficiency of electric motors and transformers Reliability and safety have become accepted as natural attributes by the users of steel.

The American steel industry today is globally competitive and market-driven. Without exception, the U.S. is the principal low-cost producer for the domestic market and is now highly competitive in other world steel markets U.S. producers are competitive internationally with respect to quality and price and have lower costs than plants in Germany or Japan

The American steel industry is diverse and evolving. The advent of new technologies has opened the way for the production of more sophisticated products by EAF producers; EAF producers are developing integration strategies involving backward integration to iron unit production such as iron carbide and direct reduced iron (DRI) facilities. Likewise, integrated producers are increasingly considering processes pioneered by the "mini-mills", such as thin-slab casting, further blurring the distinction between the two.

The American steel industry today is environmentally responsible. Emissions from steel production have been reduced by over 95 percent since 1970. In addition, steel is the most recycled material. Recycling of specific products tells this tale. In 1993, the recycling rate for automobiles in the United States was nearly 94 percent. Recycling of appliances has also grown dramatically; 36 million refrigerators, washers, dryers, and water heaters were recycled in the U.S. last year. In less than 10 years, the recycling rate for appliances has jumped from 4 percent to 61.8 percent, and twenty-one states have appliance recycling rates that exceed 70 percent.

Growing public awareness and concerted recycling programs will continue to improve this record. Each year, the recycling of steel products saves enough energy to meet the electrical needs of Los Angeles for more than eight years, and saves significant natural resources. Annual steel recycling saves over $2 billion in landfill costs. By recycling scrap, steel producers conserve energy and mineral resources, preserve the landscape and ease the pressure on municipal landfills.

The American steel industry is competitive, dynamic and forward looking. Based on its recent achievements, the industry is well-positioned to meet the challenges of the next century.

A VISION FOR THE STEEL INDUSTRY OF THE FUTURE

The American steel industry has established an overarching goal to make steel the material of choice for the 21st century. The American steel industry of the future will be a strong and vibrant sector of the economy, providing high quality, value-added products to a wide array of customers in an environmentally-friendly, cost-effective manner. It will continue to be globally competitive in cost and quality, and will lead the world in innovation and technology.

The painful restructuring of the past will pay dividends in the future. The industry will be healthy, profitable, and record better economic performances than have typified the recent history. Valuable knowledge gained from addressing the competitive challenges in the last twenty years will provide a solid basis for continued success in the future.

The American steel industry will continue to improve in critical competitive areas, particularly product and process technologies, environmental processes and energy efficiency. Processes will be more closed and continuous, and will make better use of alternative energy sources and raw materials. The American steel industry will increasingly rely on domestic energy sources, including coal and natural gas, and will decrease its reliance on imported oil.

In the future, increased attention will be paid to the total environmental profile of resources. Increased recycling of steel will further reduce energy costs, provide significant savings to customers, and dramatically reduce costs of waste processing and disposal for communities. Products will be designed to be easily recycled, giving added economic and social value to the customer and consumer. Steel production will generate fewer waste products.

The increasing sophistication and application of life cycle analysis will greatly favor steel as the material of choice. Unlike other materials which are downgraded with each recycling process, high-tech steels can be recycled into high-tech steels without any loss in product quality. Increased emphasis on recyclability combined with life cycle analysis will make steel the "green" material for the future.

The landscape of the industry will be dotted with a wider variety of production facilities. The effect of fixed and variable costs on investment returns and the product requirements of the market will determine the direction of investment flows. Because of the infrastructure already in place and the diverse needs of the market, EAF and integrated plants will continue to range in size and complexity of products. Entirely new organizational structures and alliances will be created to serve new market demands, matching production processes to market-needs, and ensuring no single process will dominate steel production in the future.

Steel producers will be viewed more as providers of critical components, characterized by high value-added products engineered for specific applications, rather than as solely suppliers of a basic commodity In general, the steel producer of the future will be smaller, flexible and more focused, and will serve specific markets. The era of the steel "supermarket" producing a full line of products for every market need will fade into distant memory

New technologies and better utilization of technology will make the steel industry of tomorrow less capital intensive. Capital investment will be more effective and efficient. Lower initial investment costs will reduce barriers to the market and attract new participants. This will create a dynamic new era characterized by constant change.

The steel plant of the future will be more productive and less labor intensive. The future workforce will be highly skilled and technologically sophisticated Labor structures will be more flexible, and characterized by greater autonomy, responsibility and authority throughout the production process

COMPETITIVE PRESSURES FACING THE STEEL INDUSTRY

The American steel industry will continue to face significant competitive challenges which will influence change and force improvements in the industry's structure and performance.

Competition from imports and overcapacity worldwide may continue to have a negative impact on the industry. The American market remains the largest, most open market in the world, and attracts steel imports which often enjoy the benefit of direct governmental support. Steel production is growing among emerging economies, particularly Brazil, South Korea, China, India and Taiwan In 1985, emerging economies accounted for 7 percent of world production; by 1992 that figure had risen to over 11 percent, and is expected to continue to grow. In many of these countries, support for the domestic steel industry has been a fundamental component of economic development plans. As the world moves toward a more open trading system, the American steel industry can anticipate continued pressure from imports, and will be forced to improve efficiency to maintain international competitiveness, and to monitor the fairness of trade

Likewise, overcapacity has been an enduring feature of the world steel industry, with worldwide production capacity exceeding consumption by 20-25 percent on average for the past twenty years. In the past decade, the American steel industry has cut approximately one third of its capacity, eliminating the most inefficient operations The European and Japanese industries are beginning to make similar adjustments, but new production from emerging economies will dilute the effect of these improvements, and maintain overcapacity. In addition, overcapacity will plague specific segments of the industry as new technologies and lower investment costs allow for new market entrants.

The pressure to improve environmental performance will also remain a competitive challenge to the industry, despite the dramatic improvements made in the past fifteen years. The Environmental Protection Agency (EPA) continues to rank several primary problems inherent in steel production among the highest environmental problems, including hazardous air pollutants, worker exposure to chemicals, and global warming. Public opinion polls of environmental concerns consistently track with these rankings and support continued protection and enforcement efforts The American steel industry can anticipate continued pressure to improve processes to eliminate, prevent, contain and recycle waste products, and to reduce the costs associated with environmental controls The industry welcomes its selection by EPA to participate in the Common Sense Initiative, which is intended to seek more cost-effective approaches to environmental regulation, and supports efforts to infuse risk analysis into the regulatory process.

The steel industry will remain energy- and resource-intensive and vulnerable to volatile energy prices In the past, major energy reductions have been achieved through the implementation of new technologies, primarily the advent of continuous casting processes. Future energy reductions will be driven by a desire to improve the environment. The future will require the development of new, innovative processes to eliminate or combine process steps in production and to capture and utilize wastes. In the drive to use energy more effectively and efficiently, linking casting and rolling by direct charging and other moves away from batch processing will play an increasingly important role

Pressures to reduce solid wastes, maximize the utilization of resources and increase recycling will also factor into the future of the steel industry. Increased use of scrap material will raise issues of quality, availability, recovery, and price. The industry will be joined in this effort by its customers who will encounter similar pressures, and will form closer alliances with customers to design products to be readily recycled. In order to achieve the highest quality requirements, EAF producers will also use large quantities of virgin iron units. Increased attention to recycling will also encourage the development of productive uses for process slags.

Demands of customers and the constant drive for improved quality will continue to have a dramatic impact upon the nature of the steel industry. Steel will no longer be viewed solely as a basic commodity by either the customer or the producer. Customers will increasingly demand higher quality specialized products that optimize the end use of the material. Steel producers will focus more attention on the needs of their customers, establish closer relationships, and develop intimate knowledge of the customer's long-term strategic plans.

Competing materials will continue to threaten steel in important industrial markets. The most significant competition will come in the automotive sector, which faces increasing demands to improve fuel efficiency without compromising performance. Steel can respond to these challenges by working more closely with its customers to match steel's competitive strengths with product demands, and by capitalizing on characteristics in which steel outperforms competing materials. The industry must work diligently with customers to improve their knowledge of steel as a material and how to design and engineer products to lower costs and improve quality. These efforts will also provide inroads into markets now dominated by other materials as the benefits of steel as a material are more widely understood; the residential construction market represents a major opportunity.

Access to and the cost of capital will remain significant challenges for the steel industry. Despite improvements in productivity and efficiency, the production of steel remains relatively capital intensive. Competition for limited capital will require the industry to seek processes which optimize new capital investments. Cost of capital will force producers to concentrate new investment in the most efficient and productive facilities. The cost and availability of capital will also continue to drive technological development. The industry will seek new production processes which eliminate or combine production steps, reduce or eliminate waste and improve yields. The industry will maintain a focus on continuous improvements in quality, productivity and efficiency.

The steel industry will also feel the effect of changing manufacturing philosophies. Whereas the steel industry was once characterized by a limited number of basic products, a plethora of specialized products will flourish in the industry of tomorrow. The concept of flexible manufacturing will be seen most dramatically in the increase in post-processing steps. New surface treatment processes will proliferate to provide customers with higher value-added products that optimize the final use. As the varieties of coatings increase, coating facilities will be designed to provide maximum flexibility to accommodate new processes and allow for innovations and combinations of coating processes to further enhance the final product.

Like all manufacturing, the steel industry will also feel the effects of the information revolution. In seeking to produce higher value-added products in fewer steps and at a lower cost, the steel industry must focus on the implementation of advanced process controls and sensors to monitor all aspects of the steelmaking process. These sensors will help producers maintain more uniform properties and detect and remedy problems during production, cutting waste and increasing yields. Advanced process controls and sensors will also give producers the power to predetermine the final product during production and to more closely match final product properties to customer specifications in the most cost effective manner

Advanced information technology will play a key role in both process controls and management systems. Advanced information and process control systems for production will make more information available throughout the plant in real time, and enable improved performance from all personnel in the plant. The workforce of the future will be multi-functional, independent and responsible for both production and maintenance of the facility. In the last task, new sensors will give personnel the ability to monitor the performance of equipment, detect changes, and avert problems before a breakdown occurs. The advent of these technologies will also require new management practices to provide increased authority to the workforce, and greater ability to detect, analyze, and resolve problems. Production decisions will increasingly devolve to the plant floor and require continuous education and training.

TECHNOLOGY CHALLENGES

In order to preserve and strengthen steel's enviable position as the leading supplier of materials, the industry must accomplish continuous improvements in the following areas of technology.

- Production efficiency;
- Recycling;
- Environmental engineering; and
- Product development.

PRODUCTION EFFICIENCY

The steel industry will continue to seek improvements in energy efficiency to reduce pollution, control production costs and limit exposure to fluctuating energy costs. Both integrated producers and EAF producers have improved efficiency in the past through implementing better technologies. This continuous improvement in production efficiency will be reflected in higher quality products and lower costs.

Future technologies may eliminate some process steps, such as the need to make coke, but add others, such as pre-heating of scrap. Maximum use of in-plant energy sources will occur, and plant residues will continue to be sold as by-products of steelmaking. Processes will be more closed and continuous, utilize a variety of energy sources and limit, capture and utilize waste. This process will continue on many fronts; the following improvements should be pursued:

- Continue to improve cokemaking and ironmaking,
- Demonstrate a commercially viable direct iron smelting process based on domestic fuels and iron-bearing materials;
- Extend the implementation of energy saving systems such as the direct rolling system;

- Evaluate new revolutionary processes, e.g. the use of carbides for direct steelmaking;

- Improve scrap utilization for the production of steel;

- Develop additional sources of virgin iron units for EAF producers;

- Continue developments to improve EAF steelmaking, including heat recovery;

- Continue developments toward near net shape casting;

- Continue developments in rolling, annealing, and finishing processes for cost/quality enhancements;

- Continue to develop advanced process controls;

- Develop advanced systems for predictive maintenance.

- Continue developments of process and information technology to enhance process integration and flexibility;

- Pre-heating of scrap or pre-reduction of ores with furnace off gases to reduce energy consumption,

- Increases in production rates of continuous casters.

The technological sophistication that will be required for production efficiency will demand a more highly skilled workforce. Continuous training and education of personnel will be required to insure the full benefits of new investments in advanced technology are realized.

RECYCLING

In the future, recycling will play an even greater role in the industry than today. Production of steel from scrap will approach 70 percent. Recycling of plant solid wastes will increase. This will require the following:

- Better recovery systems;

- Better separation and processing to raise quality;

- Teaming with customers to design products that minimize elements which adversely affect scrap quality;

- Development of new sources of iron units to upgrade EAF steel quality;

- Alternative ways to treat and to recapture the iron units and other valuable metallic residuals from electric furnace dust;
- Maximum recycling of all steel plant wastes.
- Expand and improve infrastructure to collect post-consumer steel for recycling.

EAF producers and integrated companies should collaborate in a national drive to improve scrap utilization, comparable to the Japanese "Mega" project which is supported with government funding from the Japanese Ministry of International Trade and Industry (MITI). There is also a role for public involvement in such an effort.

ENVIRONMENTAL ENGINEERING

Lean and flexible manufacturing in its simplest form involves the elimination of waste and non-value-added activity in all phases and operations of manufacturing. The steel industry of the future will achieve further reductions in air and water emissions and generation of hazardous wastes, and will develop processes designed to avoid pollution rather than control and treat it.

The industry will move toward total enclosure and zero emissions and waste. This will require the development of fewer, simpler, closely controlled continuous processing steps. Specific developments should include:

- Processes which will maximize production of useful co-products and minimize waste production and emissions;
- Direct smelting of iron-bearing solid waste, including EAF dust, to produce iron units and recover non-ferrous metals;
- Management of slag as a useful co-product;
- Technologies to utilize waste as by-products;
- Water treatment and reuse;
- Technologies to preheat scrap;
- Recovery of metallics from coating process waste streams.

RODUCT DEVELOPMENT

The steel industry of the future will be increasingly responsive to ever-changing market emands and the needs of its customers

The uncertainty inherent in projecting future product trends and accelerating rates of change will dictate that the steel industry of the future achieve maximum flexibility in production capabilities. Production lines must be developed to manufacture a variety of products. New facilities will also require the flexibility to utilize a variety of feed materials to achieve final product specifications in the most cost-effective manner.

Increased pressure to meet rising customer expectations for quality and product performance will require the implementation of advanced process controls and sensors. New sensors will be developed to "see, hear and feel" the process and evaluate the product during processing. This technology will allow producers to respond to orders in hours, not weeks, and to engineer properties into the product as it is being made.

The industry will increase its participation in key markets such as residential housing, construction, consumer products, containers, and infrastructure through the introduction of new products to meet the demand for higher strength steels with improved weldability, fabricability and toughness characteristics. Recent advances in steelmaking technology and steel microstructure-property relationships have made possible a whole new family of high performance plate steels that offer major advantages for use in bridge construction. To develop families of high-performance, "clean" low-carbon steels, researchers will use such advanced processing methods as: reduced carbon content, microalloying, controlled rolling, reheat quench and tempering (QT) and accelerated cooling/direct quenching (AC/DQ)

Specific areas for development include:

- Development of radically new products in combination with other materials through customer teaming, and utilization of new process technologies;
- Enhancement of near net shape technologies;
- Compact annealing;
- Better finishing processes with flexibility to produce variety of finishes;
- Computer modeling and simulated service testing to improve prediction of service performance.

RESEARCH PRIORITIES

The American steel industry is engaged in major collaborative efforts to achieve the technological advances necessary to improve its competitiveness Significant research and analysis of these needs has been conducted with the support and direct participation of the industry The industry has identified the following items for immediate and longer-term research and development·

- Commercialization of cleaner, energy-efficient, alternate ironmaking processes;

- Commercialization of processes to recycle in-plant wastes (in particular, BF, BOF and EAF dusts);
- Improved iron units for EAF and BOF charge, and other steelmaking processes (including reducing residuals in scrap and a coal-based direct reduction process);
- Develop new flexible steelmaking processes which can optimize sources of iron units and energy;
- Develop a totally continuous steel production process to allow optimization of the overall steelmaking system, including advanced process controls;
- Develop improved rolling/forming processes which will produce steels with superior properties;
- Improve coating and painting technology to optimally tailor products to specific applications;
- Cooperative work with steel users/customers to ensure that steel remains a user-friendly material of choice,
- Commercialization of a cokemaking technology to ensure a pollution-free process.
- Continue to monitor worldwide technical advances in strip casting and assess the potential for special product/property development;
- In the area of steel product technology, consider the Auto/Steel partnership cooperative research program as a possible model for other product lines;
- Continuous improvements in environmental performance via programs with equipment suppliers to develop processes designed for pollution prevention;
- Reducing the cost of oxygen via programs with oxygen suppliers and with the Electric Power Research Institute (EPRI) to raise the efficiency and bring down the cost of oxygen production. (With the introduction of smelters, consumption per ton of steel produced will continue to grow).
- Continuous improvements in waste recycling and resource recovery via research on new approaches and technologies, including biotechnology, to address process wastes;
- Research on recycling and disposal of low-level radioactive mixed waste.

The development of these technologies into processes that are affordable will help insure that steel will be the material of choice for the 21st century and that steel industry processes are more continuous, flexible, economic, and consistent with the national environmental goals.

CONCLUSION

The American steel industry has emerged from a painful restructuring with renewed strength and vitality. The industry is the low-cost producer for the U.S. market, and globally competitive on products and technologies. The steel industry remains a critical component of a healthy manufacturing economy, and important to U.S. national security interests.

Despite its resurgence, the American steel industry will continue to face significant economic and competitive challenges, including international competition, energy costs, environmental and regulatory demands, the cost and availability of capital, technological innovations and changing market demands. Given the hard experience of the past fifteen years, the steel industry expects to meet and exceed these challenges in the future.

The pressure to meet these challenges will demand increased utilization of collaborative efforts to leverage research and development investments. There are significant opportunities for partnerships between government, academia and industry, particularly in areas which encompass industry concerns and greater public policy interests, such as environmental controls, energy efficiency, and recycling. Enhanced cooperation with government will better focus public and private research activities, and ensure a greater return to society on its research investment. These opportunities should continue to receive private and public support.

The steel industry has identified top priorities for research and development activities. These priorities should form the basis for continued collaborative efforts that will include the steel industry, government, academia, customers, suppliers and interests from other industries.

APPENDIX - Additional Sources for Readers Seeking Detailed Information

Authoritative Descriptions of Industry Technology

1. "The Making, Shaping and Treating of Steel," published by the Association of Iron and Steel Engineers (AISE), 1985. This is the 10th Edition of a tome first published in 1919 and frequently referred to as "the Bible of the steel industry". Since 1985, important segments have been made obsolete by developments occurring with the electric arc furnace (EAF) producers. Numerous papers have been published by the AISE and by the Iron and Steel Society (ISS) describing these ongoing developments in their monthly publications.

2. "Iron and Steel Engineer," by AISE

3. "Iron and Steelmaker," by ISS

4. "Technological Development in the Japanese Steel Industry During the Postwar Reconstruction," published in 1993 by the Iron and Steel Institute of Japan (ISIJ) and available in English. This provides a good historical overview of the steel industry as a player in the world economy. It also complements the descriptions of steelmaking technology to be found in "The Making, Shaping and Treating of Steel."

Reports which reflect Various Aspects of the Industry's Technical Vision

5. "Forum to Identify Long-Range Research Opportunities for the North American Steel Industry," January 18 - 19, 1989 Sponsored by the American Iron and Steel Institute and hosted by Northwestern University Forty-two selected representatives from industry, academia and government heard presentations and discussions on the following topics:

   - Innovative near-net shape casting technologies
   - Sensor technology and instrumentation
   - Artificial intelligence
   - Process modeling
   - Surfaces
   - Environmental issues

   This report also documents the recommendations made by a distinguished research selection panel convened immediately following the forum

6. "MIT Workshop on Industrial Ecology and the Steel Industry," November 2-3, 1993. Sponsored by MIT and co-sponsored by AISI and the Steel Manufacturers Association (SMA), this workshop brought experts from academia, industry and government together to present and discuss key issues relating to the environment and to recycling. This

workshop also obtained recommendations from a distinguished panel convened immediately following the workshop. Industry CEO's participated in the workshop and on the panel.

7. "The Future Steelmaking Industry and Its Technologies," December, 1994 by R.R. Fruehan, H.W. Paxton, F. Giarratami and L. Lave. Prepared for the Department of Energy, this 125 page report by the Sloan Competitiveness Study team benefitted from extensive input from industry. The report identifies the major industry drivers which will influence technological developments in the industry for the next 5-25 years. Initially, the role of past drivers in shaping the current industry was examined to help understand the future developments. Whereas this report concentrates on future technologies other major factors such as international competition, human resource management and capital concerns are examined to determine their influence on the future industry. The future industry vision does not specify technologies but rather their general characteristics. Technical obstacles and the corresponding research and development required for commercialization are also detailed.

8 "Steel Product Technology," report to AISI Committee on Technology by John Burner, U.S. Steel, Craig Darragh, Timken, Steve Matas, LTV and Mal Roberts, Bethlehem. This task force report provides an analysis matrix on steel product technology needs for the principal market segments, where high value-added steel products are required. The information provided is sufficiently detailed to formulate key products on future developments

9. "Lessons From a Decade of Collaborative Research," Iron and Steelmakers, Howe Memorial Lecture, W E. Dennis, April, 1991. The history of collaborative research and development projects in the steel industry is briefly reviewed and the evolution of such projects during the 80's within AISI is examined in detail Alternative methods of organizing and managing collaborative activities are examined within the context of experience gained from previous efforts, and recommendations for the future are offered.

10 "Research of Environmentally Friendly Technology for the Utilization of Reusable Metallic Materials," brochure of the New Energy and Industrial Technology Development Organization (NEDO) detailing the "MEGA" Project in Japan, 1994 The brochure describes this project as follows: "Subsidized from the Ministry of International Trade and Industry (MITI), New Energy and Industrial Technology Development Organization (NEDO) launched in fiscal 1990 a new project named 'Research and Development on Industrial Technology for Preservation of Global Environment.' As part of this project, NEDO, with the joint research of the Japan Research and Development Center for Metals (JRCM), has been conducting research on a new steelmaking process which utilized steel scrap to save the energy consumed in the conventional process to reduce iron ore. This 'new next generation steelmaking process' should contribute to both the preservation of the global environment and the effective recycling of waste metallic materials."

To accomplish this, NEDO is undertaking a broad series of research projects, which are detailed in the brochure as follows:

"(1) Comprehensive Basic Research
    (1) Investigation of the future trend of scrap
    (2) Research and evaluation for scrap recovery / melting techniques
    (3) Evaluation of an integrated process and listing of pending tasks
(2) Research of a reclamation process for scrap metal
    (1) Study on the tramp element removal techniques using solid phase processing
    (2) Study on the tramp element removal techniques using liquid phase processing
(3) Research of an environmentally friendly scrap melting process
    (1) Study of elementary technology for pre-heating scrap
    (2) Elemental study of environmentally friendly scrap melting process
(4) Research of a new steelmaking process
    (1) System study to realize an integrated process
    (2) Design and construction of the integrated test plant
    (3) Overall linkage verification test using the integrated test plant "

11 "New Technologies: Making Steel the Material of Choice for the 21st Century," B Attwood, AISI General Meeting, May 18, 1994 This paper describes the introduction of new and improved products which have been made possible through the intensive capital investment strategy adopted by the steel industry over the past ten years Steel's improved reliability has translated into cost savings for both the steel industry and the customer

12 "Improved and/or New Processes," B J Fedak and J A Sakala, AISI General Meeting, May 18, 1994 This technical paper describes the capital spending over the last ten years of over $35 billion on equipment and facilities by the North American steel industry in improving productivity and quality of steel products.

Authoritative Sources of Statistical Information

13 "Annual Statistical Report," American Iron and Steel Institute

14 Numerous publications and resources of the Steel Recycling Institute

15 Steel Manufacturers Association Principal trade group for electric furnace steel producers Maintains numerous resources on the specific characteristics and concerns of this segment of the industry

TEEL

A NATIONAL RESOURCE FOR THE FUTURE

May 2, 1995

This Compact is a voluntary collaborative effort between the steel industry and the US Department of Energy. The purpose of the Compact covering both the integrated and electric furnace producers is to provide the framework for identification of the appropriate areas for joint research, development and technology demonstration. The result will be a research partnership between the Department of Energy and the steel industry.

The outcome from the partnership work will be the demonstration, evaluation and acceleration of new technologies and scientific insights that address several specific and crosscutting needs in the following general areas:

- production efficiency - to seek improvement in energy efficiency in order to control production costs, to limit exposure to fluctuating energy costs, and to produce higher quality products.
- recycling - to increase the role of steel recycling and recovery of iron units from plant solid wastes.
- environmental engineering - to achieve further reductions in air and water emissions and generation of hazardous wastes, and to develop new processes to avoid pollution rather than control and treat it.

The work that springs from this research partnership will be carried out in a joint Federal-Industry Program designed to develop technologies for the industry end-users. It will be guided by collaborating among: industry, associations, agencies of the federal government, universities and other major research institutions with expertise in the fields of interest.

Although product development is essential to the long-term success of the industry and part of the STEEL Program, it is also a primary basis for competition among companies through product differentiation. Therefore, projects that benefit the industry broadly rather than specific product research and development work will be addressed in this program. Other projects are best left to the individual efforts of company proprietary research and development programs.

The Compact is also intended to re-emphasize and reinforce the activities already underway in collaboration between the government, industry and the academic institutions. The steel industry is supporting precompetitive research and development projects in the production efficiency, recycling, environmental engineering and product development areas with both short-term and long-term potential. These efforts are emphasized in order to build upon the successes of the past. Examples include: smelting of iron ores and iron-bearing plant wastes and the advanced process control program.

For the future vision of the steel industry to become a practical reality, a continuing program of long-term research and development will be required. With support from the DOE and active participation by the National Laboratories some of the essential foundations are nearing completion. It is intended that this highly productive industry-government partnership should continue even after the industry has gained sufficient strength to provide most or all of the funding.

This compact expresses the intentions of the parties to pursue a collaborative research effort. It does not, however, create legal rights or obligations for any party and any party may withdraw without penalty and without being subject to remedies at law or equity.

This compact shall become effective upon execution by representatives of the United States Department of Energy, the American Iron and Steel Institute and the Steel Manufacturers Association for the industry. It shall remain in effect for two years, but may be extended by mutual agreement of the parties.

Signed this 2nd day of May, 1995, by:

Hazel R. O'Leary, Secretary of Energy

Thomas J. Usher, Chairman, American Iron and Steel Institute

Marvin Selig, Chairman, Steel Manufacturers Association

Q289. On page 463 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the FY 1996 Accomplishment Summary states: "The Metalcasting vision of the future was completed and the compact signed between the Secretary and industry."

Please provide copies of (i) this vision document and (ii) the signed compact.

A289. Copies are attached.

BEYOND 2000:

A VISION FOR THE AMERICAN METALCASTING INDUSTRY

SEPTEMBER 1995

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BEYOND 2000:

A VISION FOR THE AMERICAN METALCASTING INDUSTRY

EXECUTIVE SUMMARY

INTRODUCTION

The American metalcasting industry is committed to making itself the preferred supplier of net or near-net shape metal components beyond the year 2000.

This document is an evaluation of the current state of the American metalcasting industry and a vision for its future. The future challenges the industry faces are presented against the backdrop of its history and its important characteristics.

It is this vision's purpose to facilitate the formation of collaborative partnerships with public and private sector organizations, so that the industry's future challenges can be met.

THE AMERICAN METALCASTING INDUSTRY

Metalcasting is a diverse industry. Different metals are cast by many different processes, for many different applications. Cast metal products and processes offer advantages unavailable from products made by other metal forming and fabricating techniques. The industry's future is based upon these advantages.

The industry ships about 13 million tons of castings annually, valued in excess of $20 billion. Castings of ferrous metals account for 85% of tonnage shipments and 61% of the value of shipments. Nonferrous castings, primarily of aluminum, account for the rest. Major end-use markets for metal castings include the automotive, pipe, industrial machinery, transportation equipment, and aerospace markets.

The industry, which employs a total of 210,000, is dominated by small business. Of the 3,100 metalcasting establishments in this country, 79% employ fewer than 100 people.

Metalcasting is vulnerable to the cost of increasingly stringent environmental and occupational regulations. These, coupled with changing market conditions and increased global competition, have resulted in the annual loss of about 100 metalcasting establishments during the last two decades.

HISTORICAL BACKGROUND

The metalcasting industry established itself in America in 1642. Seven foundrymen are signatories of the Declaration of Independence. The industry was important in helping America through its growing pains, supplying arms and ordnance for the wars, and useful peacetime products that stimulated the Industrial Revolution and improved the quality of life.

After World War II, metalcasting experienced attrition from its ranks resulting from technological, legislative, environmental, and economic factors that caused many establishments to close. The few thousand metalcasters that remain are stronger and wiser, and fully prepared to meet their future challenges.

A VISION FOR THE METALCASTING INDUSTRY OF THE FUTURE

Metalcasting will be the preferred supplier of net or near-net shape metal components beyond the year 2000. Its globally competitive products will be produced in an efficient, environmentally friendly manner.

The painful contraction that the industry experienced in the past has left it stronger and more competitive. Through the lessons it has learned, the industry will remain profitable, know how to reinvest its earnings, and yield a reasonable return to its investors.

Through continued collaborations between the industry and its partners, its research agenda will focus on projects that will best serve its customers, its products' competitiveness, its productivity, and the environment.

Metal castings will be made using processes that will not damage the environment. Determinations made by characterizing the industry's waste streams and reasearch into methods of their elimination will make metalcasting processes cleaner.

The industry will improve the perception of cast metal products in the marketplace. Its products will be viewed as necessary 'engineered components,' not as commodities. Metalcasting will strengthen its position in existing markets, recapture lost markets, and seek new markets for its products.

Metalcasting will offer challenging careers and well-paying employment opportunities. It will attract qualified personnel by supporting students who show interest in metalcasting careers, offering opportunities for professional enrichment, and becoming more active with high school vocational arts programs.

Foundries and diecasters will improve their already strong relationships with their suppliers. Through their products and people, suppliers have given the industry dramatic gains in productivity and quality.

Metalcasters of the future will be:

- The preferred suppliers of engineered, net-shape, quality metal components.
- Globally competitive.
- Environmentally responsible.
- Well capitalized and profitable.
- A source of challenging and well-paying careers.
- The world's benchmark for technology and innovation.
- Supportive of a strong supplier base.

In order to achieve these elements of its vision, the industry must overcome certain key challenges. These may be categorized as: market and casting application development; materials and manufacturing technologies; environmental technologies; human resources, education, and training; industry health and profitability; and partnerships and collaborations.

A DIVERSE INDUSTRY--A UNIFIED VISION

The industry prides itself on its diversity and the economic agility that derives from it. Future challenges to this industry will come less from competition among metalcasters than from competing metal forming techniques, competing materials, and competing countries. These challenges can be met successfully only if the industry sets common goals and defines a means by which they can be achieved.

KEY CHALLENGES

There are a number of key challenges, many technological, that the industry must meet if it is to achieve this vision:

- Increase ***market development*** activities to improve market share in current markets by 10%, recapture 25-50% of lost markets, and increase the rate of new market development.

- Develop ***materials technologies*** to improve the variety, integrity, and performance of cast metal products.

- Develop advanced ***manufacturing technologies*** to increase productivity 15%, reduce average lead times 50%, and reduce energy consumption 3-5%.

- Develop ***environmental technologies*** to achieve 100% pre- and post-consumer recycling, 75% beneficial re-use of foundry by-products, and the complete elimination of waste streams.

- Renew emphasis on ***human resources, education, and training*** to attract sufficient talent to the industry, and to keep present employees current with latest technologies and techniques.

- Use industry's ***health and profitability*** to increase financial resources available to fund research, educational, and marketing programs by 10%.

- Encourage ***partnerships and collaborations*** to combine the experience, resources, and knowledge available in public and private sector organizations.

Market Development

The development of new markets and applications is important to the industry's future. To stay competitive, the industry will improve the products and innovate the processes it offers its customers.

Important areas of research that will contribute to this effort include:

- Improve lost foam casting technology.

- Define the advantages of semi-solid and squeeze casting technologies.

- Develop new casting alloys.

- Develop cast metal matrix composites.

- Improve control and interaction of process variables.

Materials Technologies

Metallurgy and materials technologies will be of primary importance.

Progress in the following areas will provide the industry major benefits:

- Improved dimensional control of castings.
- Elimination of casting defects such as porosity and inclusions.
- Clean cast metal technology.
- Castings with thinner walls.
- Identification and standardization of cast metal properties.
- New casting alloys.

Manufacturing Technologies

The industry will increase overall productivity 15%, reduce average lead times by 50%, and reduce energy consumed by 3-5%.

Industrial productivity is constantly being studied and improved. The full potential of new manufacturing technologies must be realized. Metalcasters will exploit this potential and strengthen its competitiveness through research in the following areas:

- Control and interaction of process variables.
- Automated finishing equipment.
- Breakthroughs in affordable automated equipment.
- Improved core removal methods.
- Extended diecasting die life.
- Lead time compression.

Given the importance of energy, and its finite supply, the metalcasting industry will find ways to use it more efficiently. The industry depends on the availability of reasonably priced energy, and the following research goals will help ensure its continued supply:

- Waste heat recovery and re-use.
- Cupola furnace modeling and control using neural networks.
- Advanced sensors and process controls.
- Melting and holding furnace optimization.

Environmental Technologies

Metalcasting has been a recycling industry for its entire history. The main feedstock of many foundries is post-consumer scrap, which is re-melted and formed into new useful products.

The industry's recycling record is extraordinary, but it is still the target of many environmental regulations. To meet its vision the industry must increase its 'greenness.' Metalcasting will find ways to enhance the cleanliness of its processes, increase both pre- and post-consumer recycling, and explore ways to reduce, and eventually eliminate, its waste streams.

Successful research in the following areas will help achieve these goals:

- Complete characterization of waste streams for process modification.
- Advanced waste treatment technologies.
- Environmentally benign sand binders and additives.
- Improved methods of sand reclamation.
- Beneficial re-use of foundry sand and other solid waste products.
- Alternative processes or materials for reduced waste generation.

Human Resources, Education, and Training

The metalcasting industry's chief asset (beside its customers) is its people. The industry believes that education is the most effective way to address its future human resource challenges. Continued educational programs of various types are among the wisest investments it can make.

The following initiatives will be improved or added to the industry's educational programs:

- Increased in-house education and training.
- Attract more college students to metalcasting curricula.
- Sponsorship of high school vocational/apprenticeship programs.
- Increase industry support for cooperative education programs.
- Increased partnering with state and local government agencies.

Profitability and Industry Health

The metalcasting industry of the future will be profitable. The results of its aggressive research programs will improve metalcasters' financial operating results. These profits will enable the industry to further invest in its future:

- More R&D spending.
- More collaborative partnerships.
- Additional spending on new plants and equipment.
- Increased educational investments.

Partnerships and Collaborations

The metalcasting industry will reach its vision through further collaborative partnerships. This industry has long known the value of these partnerships and of the resources and expertise its partners have contributed to research and educational efforts. Partnerships with government agencies, supplier companies, non-profit professional societies, and academia will be the cornerstone of the industry's future competitiveness and technical sophistication.

CONCLUSION

The metalcasting industry will be the preferred supplier of net shape metal components beyond the year 2000, but it faces significant competitive and technological challenges along the way. The industry views these challenges as opportunities for success, growth, and industrial leadership. It also recognizes that collaborative arrangements with partners from various public and private sectors are necessary for its successful evolution.

BEYOND 2000:

A VISION FOR THE AMERICAN METALCASTING INDUSTRY

THE AMERICAN METALCASTING INDUSTRY

The metalcasting industry is highly segmented and diverse. It includes sand casting, investment casting, lost foam casting, permanent mold casting, centrifugal casting, and diecasting, as well as variants on these methods. The term 'foundry' is applied to all but diecasting operations. The term 'metalcasting' applies to the entire industry of melting (or founding) metal, and pouring the molten metal into a mold for the purpose of achieving a desired shape.

Metalcasting offers advantages that no other processes can. The industry's future is based upon these advantages. The following are what make metalcastings important to designers and specifiers of components:

- Cast components are net or near-net shape.
- Almost all metals and alloys can be cast.
- There are almost no restrictions on part weight or size.
- Intricate parts can be produced as single cast components.
- Castings can be manufactured to include complex interior cavities.
- All the industry's products are fully recyclable.

There are 3,100 metalcasting establishments located in the U.S. that produce castings and diecastings of gray iron, malleable iron, ductile iron, steel, aluminum, magnesium, brass, bronze, and other metals. Roughly 15% of these establishments are diecasting facilities.

In 1994, domestic metalcasters shipped about $23 billion, or 13 million tons of product. Ferrous castings account for 61% of the value of shipments and 85% of total tonnage. Nonferrous castings, particularly aluminum products, account for the balance of shipments. Major end-use markets for metal castings include the automotive, pipe, industrial machinery, electric power, aerospace, transportation equipment, and other sectors.

The industry provides 210,000 jobs, 170,000 of which are production workers whose per capita output has increased 19% since 1992. The average production worker earns $10.75 per hour, and salaried engineers typically earn about $50,000 annually.

A unique characteristic of the industry's population is its predominance by small businesses. Of the 3,100 metalcasting establishments, 38% employ fewer than 20 people; 63% fewer than 50 people; and 79% fewer than 100 people. There are 25 foundries that employ more than 1,000 people. These tend to be captive operations serving the automotive or heavy equipment markets.

Since the majority of industry participants are small businesses, the industry is very vulnerable to expensive, and sometimes unnecessary, environmental and occupational regulations. Coupled with changing market conditions and increased global competition, this has resulted in an attrition in the foundry population of about 100 establishments per year for the past two decades.

What remains is a leaner and smarter industry. It intends to maintain its competitive edge and continue in its role as an industry vital to this nation's economic competitiveness and its national security.

HISTORICAL BACKGROUND

The metalcasting industry has existed for 6 millenia, and was one of the first industries to establish itself in America in 1642. When life in the colonies became too oppressive under English rule, seven foundrymen were on hand to sign the Declaration of Independence.

The foundry industry played an important role as America went through its growing pains, supplying arms and ordnance for the wars that followed, as well as producing useful products that stimulated the Industrial Revolution and improved the quality of life. In the post World War II period, metalcasting experienced attrition from its ranks resulting from technological, legislative, and economic factors that caused many establishments to close.

The few thousand metalcasters that remain are prepared to meet the challenges of the future. The industry considers itself a strategic asset to the United States, and has prepared this vision to provide a continuing basis for collaboration with public and private sector institutions.

A VISION FOR THE METALCASTING INDUSTRY OF THE FUTURE

Metalcasting will be the preferred supplier of net or near-net shape metal components beyond the year 2000. The industry will offer quality parts to its customers on a timely, competitive basis. Its globally competitive products will be produced in an efficient, environmentally friendly manner.

The painful contraction that the industry experienced in the past has left it stronger and more competitive. The knowledge and experience acquired in meeting the challenges of this difficult period will pay dividends in the future. Through the lessons it has learned, the industry will remain profitable, know how to reinvest its earnings, and still yield a reasonable return to its investors.

Through continued collaborations between the industry and its partners, its research agenda will focus on projects that will best serve its customers, its products' competitiveness, its productivity, and the environment. The industry will lead the world in innovation and technology.

Metal castings will be made using processes that will not damage the environment. Determinations made by characterizing the industry's waste streams and reasearch into methods of their elimination will make metalcasting a cleaner industry.

The industry will improve the perception of cast metal products in the marketplace. In the future the industry's products will be viewed as necessary 'engineered components,' not as commodities. Metalcasting will strengthen its position in existing markets, recapture lost markets, and seek new markets for its products.

Metalcasting will offer challenging careers and well-paying employment opportunities. It will attract qualified personnel by supporting students who show interest in metalcasting careers, offering opportunities for professional enrichment, and becoming more active with high school vocational arts and school-to-work programs.

Foundries and diecasters will improve their already strong relationships with their suppliers. Supplier companies have been the most significant conduit for transfering new metalcasting technology to the shop floors. Through their products and people, suppliers have given the industry dramatic gains in productivity and quality.

Metalcasters of the future will be:

- The preferred suppliers of engineered, net-shape, quality metal components.
- Globally competitive.
- Environmentally responsible.
- Well capitalized and profitable.
- A source of challenging and well-paying careers.

- The world's benchmark for technology and innovation.
- Supportive of a strong supplier base.

In order to achieve its vision, the industry must overcome certain key challenges. These may be categorized as: market and casting application development; materials and other industrial technologies; environmental technologies; human resources, education, and training; industry health and profitability; and partnerships and collaborations.

A DIVERSE INDUSTRY–A UNIFIED VISION

American metalcasting has many segments, and it is reasonable to ask why it is important for such a diverse industry to have a single vision. All metalcasters are linked by one important characteristic: They melt metal and they introduce it into a mold cavity to form a complex shape. This is accomplished in many different ways, but the industry believes that its very diversity makes this vision important.

The industry prides itself on its diversity and the economic agility that derives from it. Future challenges to this industry will come less from competition among metalcasters than from competing metal forming techniques, competing materials, and competing countries. These challenges can be met successfully only if the industry sets common goals and defines a means by which they can be achieved.

KEY CHALLENGES

There are a number of key challenges, many technological, that the industry must meet if it is to achieve this vision:

- Increase *market development* activities to improve market share in current markets by 10%, recapture 25-50% of lost markets, and increase the rate of new market development.
- Develop *materials technologies* to improve the variety, integrity, and performance of cast metal products.
- Develop advanced *manufacturing technologies* to increase productivity 15%, reduce average lead times 50%, and reduce energy consumption 3-5%.
- Develop *environmental technologies* to achieve 100% pre- and post-consumer recycling, 75% beneficial re-use of foundry by-products, and the complete elimination of waste streams.

- Renew emphasis on ***human resources, education, and training*** to attract sufficient talent to the industry, and to keep present employees current with latest technologies and techniques.

- Use industry's ***health and profitability*** to increase financial resources available to fund research, educational, and marketing programs by 10%.

- Encourage ***partnerships and collaborations*** to combine the experience, resources, and knowledge available in public and private sector organizations.

MARKET DEVELOPMENT

No vision for any industry is possible unless it produces useful, viable products. Although the metalcasting industry is diverse, its ultimate unity will be defined by its products.

The development of new markets and applications is important to the industry's future. There is little doubt that existing casting markets will change and new ones will emerge. To stay competitive under these dynamic conditions, the industry will continue to study ways of improving the products and innovating the processes it offers its customers. In addition to developing new markets, the industry intends to increase its share in current markets by 10% and recapture 25-50% of markets that it has lost.

Important areas of research that will contribute to this effort include:

- Improve lost foam casting technology to make the process more useful to the ferrous castings segment.

- Define the advantages of semi-solid and squeeze casting technologies and the market niches they will fill.

- New casting alloys for improved mechanical and thermal properties.

- Cast metal matrix composites to improve strength-to-weight ratios for automotive aerospace, computer, and other applications.

- Control and interaction of process variables to improve product quality and reduce the rate of scrapped product.

Today's metalcasting industry is market driven and technically sophisticated. This fact is often lost on those unfamiliar with the industry. As emerging technologies are proven on the shop floor, the industry's improved capabilities need to be marketed to its customers. Successful metalcasters understand the importance of marketing through carefully cultivated customer relationships.

Technology alone will not open new markets. The industry will also have to find ways to enlighten product designers and customers as to its capabilities. Getting castings specified for a product is a difficult, time consuming process. This is especially true in automotive and aerospace markets. Aggressive marketing strategies, such as in-house design services, will be necessary to reclaim lost markets and open new ones.

In the long run, the importance of competition against other domestic metalcasters will decline. For the industry to be the preferred method of producing net shape metal components it must effectively compete against other metalworking or metal fabricating processes, advanced nonmetallic materials, and foreign metalcasters.

MATERIALS TECHNOLOGIES

Metallurgy and materials technologies will be of primary importance. An important tool with which the industry will keep its products competitive is applied research on the composition and thermomechanical behavior of the metals it casts.

Progress in the following areas will provide the industry major benefits:

- Improved dimensional control of castings to improve net-shape capabilities.
- Elimination of casting defects such as porosity and inclusions to improve product quality and performance.
- Clean cast metal technology to improve product integrity.
- Castings with thinner walls to yield lighter components.
- Identification and standardization of cast metal properties so that all metalcasters and designers are using similar products.
- New casting alloys to better compete with the sometimes higher strengths offered by forged products.

MANUFACTURING TECHNOLOGIES

It is the industry's goal to increase overall productivity (defined by tonnage produced per production worker) 15%, reduce average lead times by 50%, and reduce energy consumed (per unit value of shipments) by 3-5%.

Metalcasting represents the confluence of a wide assortment of technologies. Some are unique to metalcasting, others relate more to efficient manufacturing. Among the industry's most important manufacturing technologies are melting/heating, industrial automation, computer, and process controls. Effective use of the tools the industry has available to it is one of the key challenges it faces.

Industrial productivity is constantly being studied and improved. Modern technologies and management practices have increased average tonnage produced per employee significantly. Through rapid prototyping techniques, the time required to produce a casting from a concept or CAD design has decreased significantly. Increased use of robotics has improved productivity and worker safety.

Modern metalcasters have computational hardware and software tools that have streamlined and modernized casting production in quantum leaps. The use of personal computers has shattered technological barriers that once limited metalcasters. Sophisticated sensors can now be linked to computers to control a process and its critical parameters in real time. These, in turn, can be linked to other computers to form a network that controls an entire plant. Predictive software can be used to design parts and molds, eliminating the high cost of trial and error runs or expensive tooling modifications.

The implications are enormous and brighten the industry's future. Process parameters that influence the quality of metal poured will be adjustable during the process. Programmable devices will perform the most dangerous, time consuming, or repetitive tasks. Lead times will be reduced by orders of magnitude. Diecasting die life will improve dramatically.

The full potential of new manufacturing technologies must be realized. Metalcasters will exploit this potential and strengthen its competitiveness through research in the following areas:

- Control and interaction of process variables to better control the quality of the finished product.
- Automated finishing equipment (robots) to decrease labor content and speed up an otherwise slow process.
- Breakthroughs in affordable automated equipment to encourage its more widespread use and improve industry productivity.
- Improved core removal methods to streamline production and decrease the labor content of castings.
- Extended diecasting die life to improve manufacturing performance and keep die castings price competitive.
- Lead time compression to get products to market faster than any other process.

Metal casting is energy intensive. Significant amounts of electricity and/or fossil fuels are required to keep molten metal flowing. Given the importance of energy, and its finite supply, the metalcasting industry will find ways to use it more efficiently.

U.S. metalcasters consume about 250 trillion Btus of energy each year. Most of it is used for major operations such as melting, molding, and heat treating. The major fuels used are electricity and natural gas. The diecasting segment estimates that its energy costs account for nearly 25% of the cost of its products. For other foundry processes it is estimated that energy accounts for 15% of total cost.

The industry's survival depends on the availability of reasonably priced energy, and pursuit of the following research will help it ensure its continued supply:

- Waste heat recovery and re-use to promote energy efficiency and lower operating costs.
- Cupola furnace modeling and control using neural networks to improve energy efficiency, environmental compliance, and product quality.
- Advanced sensors and process controls to optimize process energy use.
- Melting and holding furnace optimization to conserve energy without interrupting the supply of molten metal to molds or wasting metal that has already been melted.

ENVIRONMENTAL TECHNOLOGIES

Metalcasting has been a recycling industry for its entire history. The main feedstock of many foundries is post-consumer scrap, which is re-melted and formed into new useful products. This is material that is going back into the economy, and not dumped into landfills.

The industry's recycling record is extraordinary, but it is still the target of many environmental regulations. Though well intentioned, these are sometimes excessive and are partly responsible for the demise of about 2,000 metalcasting establishments in the last twenty years. Nonetheless, the industry has learned to live with environmental legislation.

However, in order to meet its vision the industry must increase its 'greenness.' In doing so, it will make itself less vulnerable to the agenda of lawmakers and political interest groups. To achieve this, programs that address recycling, treatment, and/or reduction technologies for all emissions will remain a critical component of the industry's research agenda. Metalcasting will find ways to enhance the cleanliness of its processes, increase both pre- and post-consumer recycling, and explore ways to reduce, and eventually eliminate, its waste streams.

Advances in the following areas will help achieve this goal:

- Complete characterization of waste streams for process modification.

- Advanced waste treatment technologies and utilization to seek ways to eliminate waste streams from plants.

- Environmentally benign sand binders and additives to increase employee safety and eliminate toxic waste streams from sand binder systems.

- Improved methods of sand reclamation (intraplant) to decrease the amount of virgin sand required for each mold.

- Beneficial re-use of foundry sand and other solid waste products in applications such as flowable fill, road beds, etc.

- Alternative processes or materials for reduced waste generation.

HUMAN RESOURCES, EDUCATION, AND TRAINING

The metalcasting industry realizes that its chief asset (beside its customers) is its people. The industry cannot hope to achieve its vision without trained people in sufficient numbers. There is presently a shortage of skilled labor in the industry. Though a number of universities offer metalcasting courses to future engineers and managers, there is concern for the vocational side of the industry. Few high schools have vocational arts programs that teach metalcasting skills or any programs that match the needs of this industry.

Compounding the problem is the metalcasting industry's lack of high-tech, glamor status. As a result, the industry sometimes experiences difficulty in attracting young people into it, though many who are attracted find it rewarding enough to make it their life's work.

The industry believes that education is the most effective way to address its future human resource challenges. Continued educational programs of various types are needed for the industry to prosper. The industry sees these programs as among the wisest investments it can make.

The following initiatives will be improved or added to the industry's educational programs:

- Increased in-house education and training.

- Attract more students to metalcasting curricula at the college level through financial aid and standardized course offerings.

- Industry involvement with and sponsorship of high school vocational, apprenticeship, and school-to-work programs.

- Increase industry support for cooperative education programs.

- Increase partnering with state and local government agencies.

PROFITABILITY AND INDUSTRY HEALTH

The metalcasting industry of the future will be profitable. The results of its aggressive research programs will favorably impact metalcasters' financial operating results. The money generated from these profits will enable the industry to further invest in its future:

- More R&D spending.
- More collaborative partnerships.
- Additional spending on new plants and equipment.
- Increased educational investments.

Strong financial results will make the industry more credit worthy. Lenders are often reluctant to commit financial resources to basic industries, which are subject to th yoke of environmental compliance and its associated financial liabilities. A more profitable metalcasting industry will open up credit markets, making metalcasting operations acceptable risks to banks and other lending institutions. This will give the industry additional capital needed to upgrade its operations.

In the future, metalcasting's stiffest competition will come from competing metal forming processes (forging, welding, mechanical assembly), advanced nonmetallic materials (plastics, ceramics), and foreign metalcasters. These are competitive.threats that the industry knows how to successfully counter, but the intensity of the competition is expected to increase. In order for the industry to become the preferred supplier of net shape metal components, a portion of its financial gains will be reinvested to improve its competitive position. This is where successful investments in new technologies and education will pay their best dividends.

PARTNERSHIPS AND COLLABORATIONS

The metalcasting industry will reach its vision through further collaborative partnerships. This industry has long known the value of these partnerships and of the resources and expertise its partners have contributed to research and educational efforts. Partnerships with government agencies, supplier companies, non-profit professional societies, and academia will be the cornerstone of the industry's future competitiveness and technical sophistication.

The industry's largest partner will be the U.S. Government. In the past several year the federal government has invested approximately $50 million, much of which was matched by the industry, in metalcasting research. The Department of Energy has been the largest participant, but NIST, NASA, NSF, and the Bureau of Mines have also been tive. It is the industry will seek to continue and expand these partnerships in the ırsuit of this vision. The same is true of partnerships with government at the state and :al levels.

The industry will continue its strong relationship with its supplier base--by far its ›sest partner. Suppliers' contributions to the industry's increased productivity and ality have been of paramount importance, and suppliers have been acknowledged as : primary technology transfer mechanism throughout the industry.

Trade societies, sometimes in consortia with each other, will continue in their role as ırshalls of the industry's overall research efforts. Through technical meetings, trade ›ws, and published materials, these groups will serve as hubs around which :talcasters can gather to solve common problems. They will also lead the effort to seek ancial or in-kind contributions from the industry, as many federally funded projects ļuire matching funds from industry.

Academic institutions will continue to play a major role in the metalcasting industry the future. Their major role will still be to educate scientists and engineers for careers metalcasting, but they will increasingly be involved in applied research programs.

CONCLUSION

The metalcasting industry will be the preferred supplier of net shape metal nponents beyond the year 2000. It will offer quality products to its customers at a ›bally competitive price, and it will produce them in an environmentally friendly ınner.

American metalcasting is emerging from two decades of consolidation and attrition ts ranks. What remains is an industry that is leaner, smarter, and extremely npetitive. It is a critical component of our nation's manufacturing base and an portant contributor to its economic vitality.

The industry faces significant competitive and technological challenges that, if left answered, will erode its position as a leading participant in world markets. These allenges include technological innovations in various metalcasting and nufacturing technologies, existing and new market development, training and ıcation, and partnerships.

The industry welcomes and accepts the challenges before it, and views them as portunities for success, growth, and industrial leadership. It also recognizes that laborative arrangements with partners from various public and private sectors are :essary for its successful evolution.

The metalcasting industry has identified those items most critical to its transition into the next century. It is hoped that these will form the basis of the partnerships and other collaborative efforts that will help it make this transition.

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Metalcasting

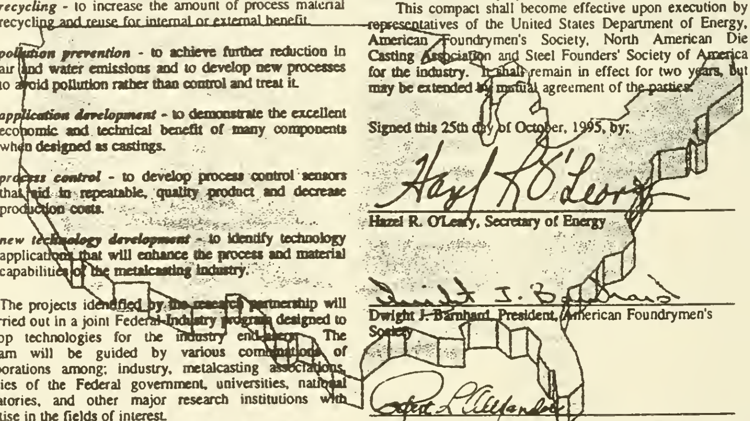
THE FOUNDATION OF THE UNITED STATES MANUFACTURING BASE

October 25, 1995

This Compact is a voluntary collaborative effort between the metalcasting industry (both foundry and die casting producers) and the US Department of Energy. The purpose of the Compact is to provide the framework for identifying appropriate areas for joint research, development and technology demonstrations. The results will be a research partnership between the Department of Energy and the metalcasting industry.

The partnership will work to demonstrate, evaluate, and accelerate new technologies and scientific insights that address several specific needs in the following general areas:

- ❑ *production efficiency* - to seek improvement in production efficiency (i.e. energy) in order to control production cost, to limit exposure to fluctuating energy costs, and to produce higher quality products.
- ❑ *recycling* - to increase the amount of process material recycling and reuse for internal or external benefit.
- ❑ *pollution prevention* - to achieve further reduction in air and water emissions and to develop new processes to avoid pollution rather than control and treat it.
- ❑ *application development* - to demonstrate the excellent economic and technical benefit of many components when designed as castings.
- ❑ *process control* - to develop process control sensors that aid in repeatable, quality product and decrease production costs.
- ❑ *new technology development* - to identify technology applications that will enhance the process and material capabilities of the metalcasting industry.



The projects identified by the research partnership will be carried out in a joint Federal-Industry program designed to develop technologies for the industry end-user. The program will be guided by various combinations of collaborations among; industry, metalcasting associations, agencies of the Federal government, universities, national laboratories, and other major research institutions with expertise in the fields of interest.

Although process/product development is essential to the long-term success of the metalcasting industry as a whole, it is also a primary element for competition among companies through product differentiation. Therefore, pre-competitive projects that benefit the industry broadly will be addressed in this program. Specific product development is best left to the efforts of individual company's proprietary research and development programs.

The Compact is also intended to re-emphasize and reinforce the activities already underway in collaboration between the government, industry and academic institutions. The metalcasting industry is supporting pre-competitive research and development projects in the production efficiency, recycling, pollution prevention, application development and process control areas with both short-term and long-term potential. These efforts are emphasized in order to build upon the successes of the past. Examples included cupola modeling, clean steel technology, and a characterization of die cast alloy properties. For the future vision of the metalcasting industry to become a practical reality, a program of long-term R&D will be required.

This compact expresses the intentions of the parties to pursue collaborative research efforts. It does not, however, create legal rights or obligations for any party and any party may withdraw without penalty and without being subject to remedies at law or equity.

This compact shall become effective upon execution by representatives of the United States Department of Energy, American Foundrymen's Society, North American Die Casting Association and Steel Founders' Society of America for the industry. It shall remain in effect for two years, but may be extended by mutual agreement of the parties.

Signed this 25th day of October, 1995, by:

Hazel R O'Leary

Hazel R. O'Leary, Secretary of Energy

Dwight J. Barnhard

Dwight J. Barnhard, President, American Foundrymen's Society

Robert L Alexander

Robert L. Alexander, President, North American Die Casting Association

Vaughn W. Makary, President, Steel Founder's Society of America

290. On page 464 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Industries of the Future, it is stated: "In response to the Industries of the Future initiative and consistent with the Galvin Commission findings that the National Laboratories and facilities must work as a team, a Memorandum of Cooperation' was signed by DOE National Laboratories and facilities. Sixteen National Laboratories and facilities have formed a coordinating council to work cooperatively with the IOF industries to determine in what areas the capabilities of the National Laboratories and facilities can best be utilized to address future technology needs of the industry."

Q290a. Please provide a copy of this "Memorandum of Cooperation."

A290a. The Memorandum of Cooperation is attached, as well as a copy of the charter of the corresponding university agreement for the forest products industry entitled *The Pulp and Paper Education Research Alliance (PPERA).*

Q290b. Please provide the names of the individuals on this coordinating council and a copy of its charter.

A290b. The names on the Memorandum of Cooperation are:

R. Bruce Thompson, Ames Laboratory
Harvey Drucker, Argonne National Laboratory
Mark Sakitt, Brookhaven National Laboratory
Bart Krawitz, Idaho National Engineering Laboratory
Dennis Cummings, Kansas City Plant
Joseph R. Laia, Los Alamos National Laboratory
Rod Fleischman, Lawrence Berkeley Laboratory
Robert N. Schock, Lawrence Liver-more National Laboratory
Thomas F. Bechtel, Morgantown Energy Technology Center
Bill Marshall, National Renewable Energy Laboratory
J.O. Stiegler, Oak Ridge National Laboratory
Sun W. Chun, Pittsburgh Energy Technology Center
Gerald L. Work, Pacific Northwest National Laboratory
Dan Hartley, Sandia National Laboratory
Susan Wood, Savannah River Site
William H. Thompson, Jr., Oak Ridge Y-12 Plant

Memorandum of Cooperation

Purpose

This Memorandum of Cooperation (MOC) recognizes and facilitates the ongoing resear collaborations among the participating U.S. Department of Energy (DOE) laboratories a facilities (hereafter referred to as laboratories) in support of DOE Office of Industrial Technologi strategies for "Industries of the Future" and is fostering collaborative research ties between the organizations. Accordingly, this MOC outlines the general nature of the ties among the parti and identifies activities intended to stimulate and foster collaboration among researchers. Th MOC is intended to provide a basis from which specific agreements and activities will grow and not intended to limit interactions to those contained herein.

Background

Capabilities such as process science and engineering technology, computer modeling, co [illegible]ment, environmental technology, energy technology, sensors and controls, materials, a [illegible]ology have been developed at the DOE national laboratories in the course of performi their DOE mission. These combined capabilities have evolved in recent years to represent significant national resource for development and application of technology in support of the maj industrial process industries of the United States. The Department of Energy, Office of Industr Technologies, has organized its activities in support of seven key process industries that are maj energy consumers, face significant environmental challenges, and are vital to the United Stat economy. These industries are:

Aluminum
Chemicals
Glass
Metal Casting
Forest Products
Petroleum Refining
Steel

For each industrial area mentioned above, a "Vision of the Future" is being developed representatives of the respective industry that outlines the current state of the industry, the desir state of the industry in the defined future , and the technology issues that need to be addressed allow the industry to reach its desired goals. The industries are working cooperatively with t DOE and other Federal Agencies to leverage their resources, to meet common goals.

A common request from each of the industrial areas is that the facilities and the expertise of t DOE system be made available in the most efficient and cost-effective manner possible. T laboratories have increasingly become cognizant of the need for collaborative multi-laborato approaches to most effectively address the needs of industry and the DOE. The past combining resources has worked to the benefit of the government-sponsored research, the industry, and of t researchers in enhancing technical productivity.

Memorandum of Cooperation

Basis for the Agreement

nilarities between the research focus and missions of the laboratories are not coincidental. ›llaboration and common research interests have resulted in the communion of missions. The eds of the nation relative to natural resource development and environmental protection have ntributed significantly to the present research focus of all the laboratories.

e seven U.S. industries that are addressed by the DOE strategies for "Industries of the Future" : the largest users of energy in the manufacturing sector, and due to the material intensive oughput of these industries, have the greatest potential for environmental emissions. llaboration between these laboratories offers opportunities to perform research and development yond the capabilities of these labs separately. By combining these complementary missions and ributes in a collaborative arrangement, the industries and the nation attain benefits in increased ergy efficiency, environmental effectiveness, and technical productivity that could not be realized parately.

is the policy of the laboratories with the support of and in partnership with the US DOE, to courage the development of mutually beneficial interactions in areas that can contribute to the ccess of DOE- and other entity- sponsored projects or programs at each laboratory. Continued d expanded collaboration between these organizations is economically, scientifically, and tionally desirable. Subject to continued Federal and private support in all areas of industrial ocessing, it is the intent of these laboratories to expand the existing collaboration base. This OC should provide a basis and stimulus for these interactions to continue and grow. The guiding nciples of operation for this MOC include the desire to: 1) work as a team, 2) trust one another, be responsive to the customer's needs (i.e. DOE, and the aforementioned industries), 4) make cisions based on adding value for the customer, and 5) collectively identify and resolve relevant ues.

Special Agreement Elements

e parties to this MOC will endeavor to accomplish the interactions described below.

oordinating Council-- A Laboratory Coordinating Council will be established to oversee National boratory participation in the implementation of DOE's Industry of the Future Strategies. Each boratory or Facility will appoint a member to the Council to represent its interests. The partment of Energy (HQ) will designate an *ex-officio* member of the Coordinating Council to lp ensure the best communication between the council and the department's programs. The uncil will have as its primary responsibility the development of appropriate Laboratory llaborative organizations (structures) to interact with an Industry and DOE. The types of uctures established will reflect DOE's and Industry's preferred modus-operandi for plementation of each partnership program; organizational structures established by the Council iy range from Industry/Laboratory Working Groups to creating a "Virtual" Center of cellence, for a specific industry. The Coordinating Council's primary responsibilities would be ensure that the specific Laboratory interaction mechanism created would be responsive to DOE d the Industry needs; to promote effective collaboration between the participating Laboratories; d to resolve issues that may evolve from the various activities. The Coordinating Council will eract with DOE management (responsible for the Industry Programs) at appropriate levels to ordinate the Laboratories' responses for each Industry Strategy.

Memorandum of Cooperation

The Council will operate via a chairman with an annual rotation. The Council will select th chairman and chair-elect for the next year at an annual meeting.

Coordinating Council Meetings -- Meetings will occur quarterly or as needed to assure positiv and productive collaborative efforts.

Laboratory/Industry Interactions-- Individual and/or collective Laboratory interactions wit Industry organizations will be developed in accordance with the organizational structure an modus operandi established in each Industry program. A spectrum of interactions can occu ranging from individual consultations to setting up Industry/Laboratory Working Groups i specific research areas, to establishing Industry/Laboratory teams to develop a proposal for specific project. The interactions developed will be consistent with the guidance provided b DOE management, industry, the individual laboratories industrial partnering program, and th coordinating council. The interactions in general will evolve from the Industry Visions bein defined by each Industry; this will ensure that the research activities proposed will be targete towards prioritized industrial needs.

Personnel Exchanges and Visits -- In order to encourage collaboration and assist in joint researc efforts, personnel exchanges and visits will enable staff to take advantage of opportunities fo enrichment and professional advancement. The laboratories will encourage personnel exchange wherever mutually beneficial.

Access to Scientific Equipment and Facilities -- The laboratories each have significant and uniqu research facilities and equipment that are vital to the success of the Industry Visions. Collaboratin personnel shall be given access to equipment and facilities, as appropriate, on a cooperative basi and, as applicable, to the extent permissible under their respective DOE Prime Contracts.

Intellectual Property -- Because transferring technology to commercial parties is critical to th success of the Industries of the Future, intellectual property rights developed during th performance of work covered by agreements undertaken pursuant to this MOC and to the exter available at the time and to the extent permissible under the DOE Prime Contracts, wher applicable, of the individual laboratories, shall be managed to promote the best interests of a concerned. Precise terms and conditions will be incorporated into the agreements implementin the specific activities.

Term of this Agreement

This Memorandum of Cooperation shall become effective upon the last date of signatures by th Parties. This MOC will remain in effect for a period of five (5) years from the effective date c execution thereof, and shall remain in effect until that time unless sooner terminated by direction c the Department of Energy. Any party can end their participation by providing thirty (30) day written notice. The withdrawal of any party from this agreement will not affect the continue participation of the remaining parties. This Memorandum of Cooperation may be extended upo mutual written agreement of the parties.

Memorandum of Cooperation

Bruce Thompson 5/27/95

Bruce Thompson
nes Laboratory

rvey Drucker
gonne National Laboratory

ark Sakitt
ookhaven National Laboratory

art Krawitz
aho National Engineering Laboratory

ennis Cummings
ansas City Plant

seph R Laia
s Alamos National Laboratory

od Fleischman
awrence Berkeley Laboratory

obert N. Schock
awrence Livermore National Laboratory

homas F. Bechtel
organtown Energy Technology Center

Bill Marshall
National Renewable Energy Laboratory

J.O. Stiegler.

J.O. Stiegler
Oak Ridge National Laboratory

Sun W. Chun
Pittsburgh Energy Technology Center

Gerald L. Work
Pacific Northwest National Laboratory

Dan Hartley
Sandia National Laboratory

Susan Wood

Susan Wood
Savannah River Site

William H. Thompson Jr.
Oak Ridge Y-12 Plant

THE PULP AND PAPER EDUCATION AND RESEARCH ALLIANCE (PPERA)

PURPOSE

The Pulp and Paper Education and Research Alliance (PPERA) is an alliance of universities with programs which are individually distinctive but which are similar in being committed to the advancement of the North American pulp, paper and allied industries. Each of the PPERA university partners has various supportive relationships with industry and government designed to strengthen the contributions of higher education to the pulp, paper and allied industries. In recognition of these strategic partnerships, the university programs comprising PPERA will work together to develop synergistic programs in education, research, and service which are mutually beneficial and collectively leverage contributions to the pulp, paper and allied industries. Membership in PPERA places no limitations on participating institutions.

VISION

The vision of PPERA is to maximize the individual and collective contributions of represented member institutions to the North American pulp, paper and allied industries.

MISSION

PPERA is committed to advancing the strength of participating universities and the North American pulp, paper and allied industries through the individual and collective endeavors of the related university programs. We are pledged to cooperate in attaining our common objectives in education, research, and service, for the purpose of enhancing benefits to the industry. We will pursue and develop opportunities for joint ventures in all areas which will be mutually beneficial to the university programs as well as to their respective external constituents. We will work to increase resources available for meeting the education and research needs of the North American pulp, paper and allied industries. We will share information that will assist in understanding existing resources and in identifying industry needs. We will pursue new funding opportunities from public and private sources to be utilized in areas vital to the pulp, paper and allied industries. We will collaborate with academic, industrial and governmental organizations in pursuit of our goals.

RATEGY

ERA benefits its member institutions and the North American pulp, paper and allied lustries by:

Facilitating high quality research and development programs that are vital to the pulp, paper and allied industries.

- PPERA institutions will work with the North American pulp, paper and allied industries and the professional organizations serving that industry to expand related research support and infrastructure.
- PPERA institutions will be encouraged to collaborate with each other and with industry to maximize benefits derived from research and development program expenditures.
- Faculty in PPERA institutions will be encouraged to develop joint research proposals, programs, and more extensive student and faculty interactions.
- Electronic data interchange/networking will be used whenever cost effective to advance the cause of the alliance.

Recruiting and preparing students in engineering and science programs related to the pulp, paper and allied industries.

- PPERA institutions will enhance student recruitment by encouraging the development of appropriate materials and programs describing technical capabilities of the industry and its career opportunities.
- Educational needs of the industry will be determined and advice sought through foundations and industrial advisory boards.
- Information regarding educational programs of PPERA institutions will be disseminated broadly within the academic and industrial communities.
- Faculty in PPERA institutions will be encouraged to collaborate on educational projects that benefit the institutions and the North American pulp, paper and allied industries.

C. Developing new educational and training materials.

- PPERA institutions will encourage the development of educational and training materials that can be utilized by academic, industrial and government organizations.

- Faculty from PPERA institutions will be encouraged to develop innovative educational/training materials that can be delivered via electronic media.

- Faculty in PPERA institutions will be encouraged to cooperate in providing continuing educational offerings.

D. Working with the North American pulp, paper and allied industries and the professional organizations supporting that industry to provide authoritative technical information and analysis to the public.

- PPERA institutions will, when appropriate, interface with other industry organizations to develop information on pulp and paper issues.

- PPERA institutions through their networking capabilities will identify and recommend personnel who can provide objective information on pulp and paper issues.

CHARTER MEMBERS OF THE PULP AND PAPER EDUCATION AND RESEARCH ALLIANCE (PPERA)

12/21/94
William V. Muse — Date
President
Auburn University

12/20/94
G. Wayne Clough — Date
President
Georgia Institute of Technology

Richard A. Matula — 12/16/94
Richard A. Matula — Date
President
Institute of Paper Science and Technology

Frederick E. Hutchinson — 12/22/94
Frederick E. Hutchinson — Date
President
University of Maine

Larry K Monteith — 1/5/95
Larry K. Monteith — Date
Chancellor
North Carolina State University

12/28/94
Ross S. Whaley — Date
President
State University of NY
College of Environmental Science & Forestry

MEMBERS OF THE
PULP AND PAPER EDUCATION AND RESEARCH ALLIANCE
(PPERA)

Paul G. Risser
President
Miami University

3-14-95
Date

Diether Haenicke

Diether H. Haenicke
President
Western Michigan University

2-16-95
Date

William P. Gerberding
President
University of Washington

4/26/95
Date

Keith R. Sanders
Chancellor
University of Wisconsin - Stevens Point

3-7-95
Date

Q291. On page 464 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Forest Products, it is stated: "Black Liquor Gasification–Pulsed Combustion research on pulsed-enhanced fluid-bed steam reforming, an innovative solution to the spent liquor recovery problem that provides a superior alternative to conventional recovery boiler technology currently in use in pulp and paper mills, has led to the construction of a 75 ton per day system for processing black liquor. The system has been in intermittent operation at the Weyerhauser New Bern facility since late 1993. This novel technology eliminates the danger of smelt water explosions, a major problem with conventional recovery boilers, improves conversion efficiency and reduces environmental emissions by more than 65%. Stone and Webster is currently licensing the technology from MTCI for commercialization."

Q291a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of Black Liquor Gasification–Pulsed Combustion research on pulsed-enhanced fluid-bed steam reforming, including identification of the recipients of that DOE funding.

A291a. The recipient of the financial assistance award is Manufacturing and Technology Conversion (MTCI) of Columbia, Maryland. The funding per fiscal year is indicated in the Table below.

DOE and Private Sector Funding for Black Liquor Pulse Gasifier
(In Thousands of $)

		Private Sector	
Fiscal Year	**DOE**	**Contractual Cost-Share***	**Noncontractual Cost-Share***
1990	1,395	92	245 (Weyerhauser)
1991	2,432	203	245 (Weyerhauser)
1992	1,715	230	103 (Weyerhauser)
1993	2,562	250	348 (Weyerhauser)
1994	2,143	0	258 (Weyerhauser)
1995	1,353	0	1,634 (1,500 from Stone & Webster and 134 from Weyerhauser)
1996	0	0	TBD
1997	0	0	TBD
Total	11,600	775	2,833 +TBD

*The contractual cost share represents the cost share that is required in the financial assistance award. Weyerhauser Corporation and, more recently, Stone & Webster, have made significant in-kind contributions to the project. These costs are reflected under the noncontractual cost share portion of the project.

Q291b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A291b. In accordance with 35 U.S.C 202(a) and 10 CFR 600.33(b)(1), patent rights for small business firm or nonprofit organization, the grantee may retain the entire right, title, and interest throughout the world to each subject invention, and the Federal Government has a nonexclusive, paid-up license to use the technology. For this project, MTCI is the patent holder and StoneChem, a wholly-owned subsidiary of

Stone & Webster, has an exclusive license to offer the technology in the U.S. and Canada.

Q291c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A291c. 35 U.S.C 202(a) does not provide for royalties to be paid to the government. MTCI is a small start-up company that is developing a very significant energy saving pollution prevention technology. As a start-up R&D firm, the company faces serious cash flow problems, with much more money being spent to develop potential technologies than is being taken in through sales. The technology will take at least 5-10 years to be commercially viable.

Q291d. Please document why this technology would not have been developed in the absence of DOE funding.

A291d. The technology would not have been developed without DOE support because it has a fairly high risk of failure. The benefits, if successful, are substantial, but the high risk makes the cost of the research too high for the companies to justify if they must assume the whole cost alone. In addition, MTCI is a small minority-owned business without the necessary resources to develop the technology without the benefit of government assistance.

Q292. On pages 464 and 465 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Forest Products, it is stated: "The impulse drying of paper technology has been taken from an idea to a promising reality. The technology has been successfully demonstrated at both laboratory and bench scale and will be demonstrated at a full speed pilot scale level in FY 1996. This breakthrough technology will save 1/3 of the energy required for papermaking, reduce production costs by 15 percent, improve paper strength by 25%, increase the recycled content of paper and increase productivity by 80%."

Q292a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of the impulse drying of paper technology concept to present, including identification of the recipients of that DOE funding.

A292a. The recipient of the financial assistance award is the Institute for Paper Science and Technology (IPST), an accredited university in Atlanta, Georgia. In fiscal year 1995 and expected in FY 1996, the budget will also include a subcontract to the Beloit Corporation of Beloit, Wisconsin. The funding by fiscal year is shown in the table below.

DOE and Private Sector Funding for the Impulse Paper Drying Project
(In Thousands of $)

		Private Sector	
Fiscal Year	**DOE**	**Contractual Cost-Share***	**Noncontractual Cost-Share***
1985	350	0	150
1986	200	0	100
1987	350	0	150
1988	350	0	150
1989	300	0	200
1990	200	0	200
1991	100	0	200
1992	200	0	315
1993	250	0	175
1994	1,045	0	167
1995	287	87	0
1996	1,670	418	0
1997	0	0	0
Total	**5,302**	**505**	**1,807**

* The contractual cost share represents the cost share that is required in the financial assistance award. The noncontractual cost share is the cost of projects that were conducted at EPST related to the Impulse Drying project.

Q292b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A292b. In accordance with 35 U.S.C. 202(a) and 10 CFR 600.33(b)(1), patent rights for small business firm or nonprofit organization, the grantee may retain the entire right, title, and interest throughout the world to each subject invention, and the Federal Government has a nonexclusive, paid-up license to use, the technology.

Q292c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A292c. 35 U.S.C 202(a) does not provide for royalties to be paid to the government. 10 CFR 600 provides that all non-profits (including universities) retain exclusive rights to the technology developed.

Q292d. Please document why this technology would not have been developed in the absence of DOE funding.

A292d. The IPST, like most higher education institutions in this country, is very dependent on programs like OIT's for funding to support basic and applied research and the educational base. Because of the high initial risk of this technology, industry was unlikely to support this research.

Q293. On page 465 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Steel, it is stated: "Praxair continues commercialization of post combustion technology which was developed through the Direct Steelmaking project. Post Combustion recovers much of the energy contained in electric arc furnace off gasses, thus saving 50 kilowatt hours per ton of steel while increasing productivity 6-7%. Nationwide application of this technology could save 1.6 million BTUs per year. By the end of calendar year 1995, 3.6 million tons of steel per year will be manufactured using Praxair's post combustion technology. These installations will generate $1.8 million in oxygen sales. Several installations have been sold overseas."

Q293a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of the post combustion technology, including identification of the recipients of that DOE funding.

A293a. This work was started under the Direct Steelmaking/Waste Oxide Program. DOE funding was $4,797,560 (awarded during FY1994) and cost share was $2,056,097. FY 1995 DOE funds were $837,281 and cost share was $635,673. Recipient of the funding was the American Iron and Steel Institute.

Q293b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A293b. Praxair originally developed a post-combustion technology in a subcontract to the Direct Steelmaking/Waste Oxide project for basic oxygen steelmaking furnaces. The program did not go to a commercialization stage, but Praxair has continued the development for other applications, including Electric Arc Furnaces. This application has been developed by Praxair without funding support from DOE. Praxair has the rights to employ this technology in other than direct steel making projects.

Q293c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A293c. Commercial sales of this technology for other than direct steel making does not result in any DOE royalties.

Q293d. Where overseas have "several installations" been sold?

A293d. Praxair has provided one post-combustion installation in Spain, 1-2 in Brazil, and one is being commissioned in China.

Q293e. Please provide detailed documentation of the claim that "Nationwide application of this technology could save 1.6 million BTUs per year," including the peer review process undertaken.

A293e. Praxair originally developed a post-combustion technology in a subcontract to the Direct Steelmaking project for basic oxygen steelmaking furnaces. The program did not go to a commercialization stage, but Praxair has continued the development for other applications, including Electric Arc Furnaces. When post-combustion technology is applied to electric arc furnaces the combustion of carbon monoxide provides heat that can be used in place of some of the electric energy required. In tests, a savings of 40-50 kWh/ton of steel has been shown. Praxair estimates that the technology will be applied to 3.6 million tons (out of a total market of 50 million ton/yr) and the energy required to produce a kWh is 11,000 Btu, the energy savings will be: 40 kWh/ton x 3.6 million tons/yr x 11,000 Btu/kWh = 1.6 Trillion Btu/year.

Q293f. Please document why this technology would not have been developed in the absence of DOE funding.

A293f. The direct steelmaking/waste oxide technology was (and is) considered a "high risk" technology by the conservative capital intensive steel industry. Over the past 20 years the integrated steel industry has focused its new technology capital investments on value-added end-products such as hot-dip or electro-galvanized products. Since direct steelmaking/waste oxide technology is a generic, front end technology, no domestic steel company was (or is) willing to take the economic risk associated with this type of capital investment. Consequently, without DOE providing a significant portion of the cost in demonstrating the technical and economic feasibility of the process, the technology would not have been developed.

Q294. On page 465 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Steel, it is also stated: "The Advanced Process Control project achieved its first commercial success: A user friendly computer model of the hot strip mill was delivered to the industry via a workshop training session. This model will permit steelmakers to predict the microstructure and properties of carbon steel before it is hot rolled, and to develop rolling practices for new alloys. Current research is extending this model to more sophisticated steels. When implemented throughout the industry, this technology will improve yield about 0.5%, save 2.2 trillion BTUs and $27.5 million annually. It will substantially reduce the cost of developing rolling practices for new grades of steel."

Q294a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this model, including identification of the recipients of that DOE funding.

A294a. The Advanced Process Control Program consists of six major research activities resulting from an unsolicited proposal submitted by the American Iron and Steel Institute (AISI) to DOE in accordance with the Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988. This program is funded under the Metals Initiative (Public Law 100-680). The annual program budget period is from April 30 to April 29. Program Year 3 activities began April 30, 1995. The six major research project activities are identified as Tasks A through F. The user-friendly computer model of the hot strip steel mill is being developed under Task C–Microstructure Engineering in Hot Strip Mills. The portion of the budget that has been approved for Task C is shown in the table below. It should be noted that Task C is scheduled to continue another two years. The proposed budget for these two years is not included in the Table.

Portion of the total Advanced Process Control Program budget that was approved for Task C–Microstructure
(In Thousands of $)

Budget Period	Incremental Approved Budget		
	DOE (70%)	AISI (30%)	Total (100%)
April 30, 1993 to April 29, 1994	516,036	221,158	737,194
April 30, 1994 to April 29, 1995	575,002	246,429	821,431
April 30, 1995 to April 29, 1996	804,450	344,766	1,149,216
Total	1,895,488	812,353	2,707,841

.Q294b. What is the patent/license situation with regard to this model, i.e., who holds the patent(s)/license(s)?

A294b. The latest version of the Hot Strip Mill Model (Version 3.0) was released to participating steel companies March 6, 1996. This project was funded as a Metals Initiative (Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988 - Public Law 100-680) Project. This legislation states that all patent rights shall be vested in accordance with section 9 of the Federal NonNuclear Energy Research and Development Act of 1974, which authorizes the Secretary to waive the patent rights to the participants in accordance with the following objectives:

1. Making the benefits of the energy, research, development, and demonstration program widely available to the public in the shortest practicable time.

2. Promoting the commercial utilization of such inventions.

3. Encouraging participation by private persons in the Secretary's energy research, development, and demonstration program.

4. Fostering competition and preventing undue market concentration or maintenance of other situations inconsistent with the antitrust laws.

The Metals Initiative Management Plan mandates the establishment of a holding company where the intellectual property including patents will reside. Title to all patents resulting from research authorized by the Act will be available to the holding company as a result of the Statement of Analysis and Determination of Exceptional Circumstances for DOE Funding Agreements relating to the U.S. Department of Energy Steel Initiative issued on June 3, 1987 and the provisions of an advance waiver of the Government's U.S. and Foreign Patent Rights. This method of handling intellectual property is intended to serve the dual purposes of facilitating technology transfer to the market place and providing benefits to project participants.

Participants in a Metals Initiative project and the United States Government receive a fully-paid-up royalty-free license from the holding company to all patents generated by the project. The holding company must make available nonexclusive licenses on reasonable terms and conditions to practice technology developed under this Act to all responsible domestic companies that do not participate in a project. Royalties and other fees obtained through the sale and/or licensing of intellectual property will be distributed among the participants, the holding company, research organizations, and inventors, and the Federal Government, according to agreement among these parties. The American Iron and Steel Institute had designated Steel Technology Corporation as the holding company for this project. The holding company agreement was signed June 1, 1989.

Q294c. Has (is) DOE receiving any royalties as a result of its role as a funder of this model, or will it in the future, and if not, why not?

A294c. At the present time DOE has not received any income from licensing fees for this project as commercialization activities are just beginning.

Q294d. Please provide detailed documentation of the claim that "When implemented throughout the industry, this technology will improve yield about 0.5%, save 2.2 trillion BTUs and $27.5 million annually."

A294d. The technology was estimated to result in a savings of 2.2 trillion Btu and $27.5 million annually. This estimate was based on the improved yield of 0.5% expected from the use of this technology. In the submission of the original proposal to DOE by AISI it was noted that the production of hot strip mill products with specific mechanical property attributes or with specific microstructural attributes currently requires numerous and costly full production trials before both the ranges of chemical composition and of hot strip mill processing parameters can be comfortably defined. The product types that would benefit from this technology account for about 22 million tons of American steel production. Because hot rolled products are difficult to make due to the strict property specifications, it was estimated that the new technology would provide the means to improve yield by a minimum of 0.5%. Yield loss (scrapped product) costs the industry an average of $250 per ton. Thus, the savings would be as follows: 22 million tons x 0.005 x $250 = $27.5 million. At 20 million Btu per ton energy requirement to produce the steel, this savings includes: 22 million tons x 0.005 x 20 million Btu = 2.2 trillion Btu savings.

Q294e. Please document why this model would not have been developed in the absence of DOE funding.

A294e. Over the past 20 years, the integrated steel industry has focused its new technology capital investments on value-added end-products, such as hot-dip or electro-galvanized products. Since the computer model is a generic steel making technology, no domestic steel company was (or is) willing to take the economic risk associated with this type of research effort. Consequently, without DOE providing a significant portion of the cost in demonstrating the technical and economic feasibility of the model this technology would not have been developed.

Q295. On page 465 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Aluminum, it is stated: "A rapid, non-contact surface temperature analyzer developed for the steel industry has been adapted for process control in the production of aluminum sheet materials. Over 10% of all aluminum sheet produced is rejected, largely due to improper temperature measurement. A full scale unit has been installed on an aluminum sheet production line to quantify the reduction in rejected product and the associated reduction in reprocessing costs and energy consumption. Lower cost aluminum sheet products currently represent a major cost barrier in the production in the production of cost competitive light weight vehicles in the U.S."

Q295a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this temperature analyzer, including identification of the recipients of that DOE funding.

A295a. Recipients of the DOE funding have been the Prime Contractor, Surface Combustion of Maumee, OH, and Subcontractor, Textron Systems of Wilmington, MA.

Temperature Analyzer Funding
(In Thousands of $)

	Funding		
Fiscal Year	**DOE**	**Private Sector**	**Total**
1989	135	0	135
1990	318	15	333
1992	71	11	82
1993	860	401	1,261
1994	210	0	210
Total	**1,594**	**427**	**2,021**

Q295b. What is the patent/license situation with regard to this temperature analyzer, i.e., who holds the patent(s)/license(s)?

A295b. The prime contractor, Surface Combustion, a small business, holds the patent rights for this technology used for metal undergoing heat treatment. The temperature measurement system has been patented under U. S. Patent number 5,286,313, "Process Control System Using Polarizing Interferometer", by T. Schultz et. al., which has been assigned to Surface Combustion, Inc. of Maumee, OH. The Patent was issued on February 15, 1994.

As a small business, Surface Combustion, according to 10 CFR 600.33(b)(1), "may retain the entire right, title and interest throughout the world to each subject invention." Surface Combustion has elected to do this.

Q295c. Has (is) DOE receiving any royalties as a result of its role as a funder of this temperature analyzer, or will it in the future, and if not, why not?

A295c. Under the terms of 10 CFR600.33(b)(1), no royalty payments to the U.S. are required. This project was NOT funded under the Steel and Aluminum Energy Conservation and Technology and Competitiveness Act of 1988 - Public Law 100-680.

Q295d. Please document why this temperature analyzer would not have been developed in the absence of DOE funding.

A295d. A small business organization such as Surface Combustion cannot undertake a project of this magnitude and exceptional risk without outside assistance such as that provided by DOE. Also the prime and subcontractor would not undertake this project without long term financial assistance because of the uncertainties of capital cost and availability, and the uncertain ability of this technology to compete with other sensor technologies. Additionally, budget constraints at both organizations place priorities on the funding of research alternatives associated with survival, rather than the major innovative advance developed here.

Q296. On page 465 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Aluminum, it is also stated: "Commercial use of stable TiB2-Graphite cathode was successfully demonstrated in full-scale aluminum electrolysis cells in a joint program by Reynolds Metal Company and Kaiser Aluminum Chemical Corporation at Kaiser's Mead Plant in WA. This technology will save 0.1 Quad when retrofitted to the U.S. aluminum smelters and up to 0.24 Quad when combined with the OIT inert anode program. This technology will allow the U.S. primary industry with its 130,000 employees, to retrofit their old facilities to become cost competitive in the world market while utilizing their previously invested capital. The 15% reduction in energy consumption will significantly reduce the power rate advantage currently enjoyed by the off-shore aluminum producers. Stable cathodes provide flexibility in operation that can provide energy benefits or increased capacity depending on market cycle."

Q296a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of the stable metal cathode, including identification of the recipients of that DOE funding.

A296a. The recipient of the DOE funding has been Reynolds Metal Co.

Stable Metal Cathode Funding
(In Thousands of $)

	Funding		
Fiscal Year	**DOE**	**Private Sector**	**Total**
1990	910	390	1,300
1991	1,570	673	2,243
1992	0	0	0
1993	708	303	1,011
1994	400	171	571

Fiscal Year	Funding		
	DOE	Private Sector	Total
1995	0	0	0
1996	0	0	0
Total	3,588	1,537	5,125

Q296b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A296b. This project was funded as a Metals Initiative (Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988 - Public Law 100-680) Project. This legislation states that all patent rights shall be vested in accordance with section 9 of the Federal NonNuclear Energy Research and Development Act of 1974, which authorizes the Secretary to waive the patent rights to the participants in accordance with the following objectives:

1. Making the benefits of the energy, research, development, and demonstration program widely available to the public in the shortest practicable time.

2. Promoting the commercial utilization of such inventions.

3. Encouraging participation by private persons in the Secretary's energy research, development, and demonstration program.

4. Fostering competition and preventing undue market concentration or maintenance of other situations inconsistent with the antitrust laws.

The Metals Initiative Management Plan mandates the establishment of a holding company where the intellectual property including patents will reside. Title to all patents resulting from research authorized by the Act will be available to the holding company as a result of the Statement of Analysis and Determination of Exceptional Circumstances for DOE Funding Agreements relating to the U.S. Department of Energy Steel Initiative issued on June 3, 1987 and the provisions of an advance waiver of the Government's U.S. and Foreign Patent Rights. This method of handling intellectual property is intended to serve the dual purposes of facilitating technology transfer to the market place and providing benefits to project participants.

Participants in a Metals Initiative project and the United States Government receive a fully-paid-up royalty-free license from the holding company to all patents generated by the project. The holding company must make available nonexclusive licenses on reasonable terms and conditions to practice technology developed under this Act to all responsible domestic companies that do not participate in a project. Royalties and other fees obtained through the sale and/or licensing of intellectual property will be distributed among the participants, the holding company, research organizations, and inventors, and the Federal Government, according to agreement among these parties.

Q296c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A296c. A negotiated rate has been determined and royalties will be paid once commercial sales are made. DOE will be reimbursed up to 150% of the funding made available. DOE has not yet received any royalties as a result of its role as funder of this technology. This is because the technology has not yet been sold as a commercial product.

Q296d. Please provide detailed documentation of the claim that "This technology will save 0.1 Quad when retrofitted to the U.S. aluminum smelters and up to 0.24 Quad when combined with the OIT inert anode program."

A296d. Energy consumption in an electrolytic cell is a product of cell potential times current. Production rate is proportional to current. Thus, energy consumption can be reduced, while maintaining production rate, by reducing cell potential. In a Hall-Heroult cell, the cathode is molten aluminum. In order to prevent shorting out the cell (the cathode touching the anode), a separation distance must be maintained between the aluminum melt and the carbon anodes above the melt. Because the aluminum surface can be wavy (due to the strong magnetic field in the cell), a large anode/cathode separation is maintained. With a solid cathode surface above the melt, waves are no longer a problem, and the anode/cathode distance can safely be reduced. Reducing this distance lowers the resistance to current of the molten salt electrolyte between the anode and cathode, hence the cell may be operated at lower potential, saving energy. The amount of energy saved per mass of product is estimated at 1.5 kWh/lb based on the projected reduction in anode/cathode distance attainable with the new cathode. Multiplying this by the US production rate of aluminum (about 4 million tons, annually), yields the estimated 0.1 Quad savings.

The carbon anodes are consumed during electrolysis. They are repositioned to the optimum anode/cathode distance, but this optimum is greater than that achievable with an inert anode because the carbon may wear unevenly. Hence, cell resistance increases due to greater resistance in the molten salt electrolyte. The stable (inert) anode would allow continued operation at the minimum optimal anode/cathode separation, thus allowing lower cell potential and reduced energy requirements. In conjunction with use of the inert cathode, additional savings are anticipated, estimated at a total of .24 Quad.

This benefit calculation assumes no new smelters will be built in the U.S. Existing U.S. smelter capacity will be retrofit with the new low energy smelting technology. The projected energy savings for this technology are consistent with values estimated by all of the major U.S. and Australian aluminum companies.

Q296e. Please provide detailed documentation of the claim that "This technology will allow the U.S. primary industry with its 130,000 employees, to retrofit their old facilities to become cost competitive in the world market while utilizing their previously invested capital. The 15% reduction in energy consumption will significantly reduce the power rate advantage currently enjoyed by the off-shore aluminum producers."

A296e. Recently, new aluminum capacity has been built in areas with plentiful, cheap, and underutilized hydroelectric capacity, including Africa, South America, Canada, and Indonesia. Prices for electricity in these regions are significantly less than in the U.S., but exact costs are difficult to determine as many foreign competitors receive subsidized power rates. A recent study of worldwide aluminum economics placed typical US power costs at 1.5 to 2.5 cents per kWh and those of some foreign competitors at 1 cent or lower. Because a major cost of aluminum production is the energy used in electroreduction, U.S. production must become more energy efficient in order to compete cost-wise with imported aluminum.

Q296f. Please document why this technology would not have been developed in the absence of DOE funding.

A296f. This technology was (and is) considered a "high risk" technology by the conservative, capital intensive aluminum industry. Consequently, without DOE providing a significant portion of the cost in demonstrating the technical and economic feasibility of the process this technology would not have been developed.

This R&D is high risk, long-term, and expensive because of the need to perform long-term (year or more) testing in an instrumented, commercial-size production cell. Specialty ceramics fabricators are not capitalized sufficiently to pursue such a project. U.S. aluminum refiners were suffering from decreasing profitability resulting from foreign competition, hence were reluctant to invest in long-term research.

DOE funding supplemented with significant cost-share was judged necessary to spur development of this technology. See documentation for #283c. Similar documentation for the U.S. Department of Commerce's Advanced Technology Program (ATP) has been reported (April, 1996, *Journal of Metals*). The result of a survey of 125 companies and non-profit organizations participating in ATP projects was presented. According to the survey, 70 percent of the companies interviewed reported that there was little or no chance they would have pursued the technology now under development had they not received support through the ATP. Of the balance, 90 percent reported that they would have pursued goals at a much slower pace without government funding.

Q297. On page 466 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Aluminum, it is stated: "Production of improved quality alumina with reduced energy consumption and dusting losses was demonstrated in a 100 kg/hr pilot-scale pressure calciner by Aluminum Company of America. The improved alumina dissolution properties provide up to 1% productivity increase in the existing aluminum smelters and the optimum feed material for the OIT inert anode pilot cell tests."

Q297a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this pressure calciner, including identification of the recipients of that DOE funding.

A297a. The recipient of the DOE funding has been Aluminum Company of America.

Pressure Calciner Funding
(In Thousands of $)

	Funding		
Fiscal Year	**DOE**	**Private Sector**	**Total**
1993	496	213	709
1994	428	183	611
1995	0	0	0
1996	0	0	0
Total	924	396	1,320

Q297b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A297b. This project was funded as a Metals Initiative (Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988 - Public Law 100-680) Project. This legislation states that all patent rights shall be vested in accordance with section 9 of the Federal NonNuclear Energy Research and Development Act of 1974, which authorizes the Secretary to waive the patent rights to the participants in accordance with the following objectives:

1. Making the benefits of the energy, research, development, and demonstration program widely available to the public in the shortest practicable time.
2. Promoting the commercial utilization of such inventions.
3. Encouraging participation by private persons in the Secretary's energy research, development, and demonstration program.
4. Fostering competition and preventing undue market concentration or maintenance of other situations inconsistent with the antitrust laws.

The Metals Initiative Management Plan mandates the establishment of a holding company where the intellectual property including patents will reside. Title to all patents resulting from research authorized by the Act will be available to the holding company as a result of the Statement of Analysis and Determination of Exceptional Circumstances for DOE Funding Agreements relating to the U.S. Department of Energy Steel Initiative issued on June 3, 1987 and the provisions of an advance waiver of the Government's U.S. and Foreign Patent Rights. This method of handling intellectual property is intended to serve the dual purposes of facilitating technology transfer to the market place and providing benefits to project participants.

Participants in a Metals Initiative project and the United States Government receive a fully-paid-up royalty-free license from the holding company to all patents generated by the project. The holding company must make available nonexclusive licenses on reasonable terms and conditions to practice technology developed under this Act to all responsible domestic companies that do not participate in a project. Royalties and other fees obtained through the sale and/or licensing of intellectual property will be distributed among the participants, the holding company, research organizations, and inventors, and the Federal Government, according to agreement among these parties.

In accordance with the Metals Initiative (Public Law 100-680), the Aluminum Company of America (Alcoa) has formed a holding company that will retain patent rights for this technology.

Q297c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A297c. A negotiated rate has been determined and royalties will be paid once commercial sales are made. DOE will be reimbursed up to 150% of the funding made available. DOE has not yet received any royalties as a result of its role as funder of this technology. This is because the technology has not yet been sold as a commercial product. Alcoa has estimated that the payback will be less than 1 year if fully implemented.

Q297d. Please document why this technology would not have been developed in the absence of DOE funding.

A297d. There are several reasons that industry has not pursued development of this technology. The commercialization of this technology requires development and testing of 5 different technologies combined. These include demonstration of pressurized combustion to enhance heat transfer to make the calciner cost effective, self fluidization within tubes (rather than a bed), methods of inputting material to the fluidizing tubes, discharge of hot alumina solids under pressure, and an inexpensive control system to perform on-line heat and material balances. There are risks involved in any of these concepts, and when taking together have precluded any industrial development. Alcoa would not have preceded without DOE sponsoring funds.

DOE funding supplemented with significant cost-share was judged necessary to spur development of this technology. See documentation for #283c. Similar documentation for the U.S. Department of Commerce's Advanced Technology Program (ATP) has been reported (April, 1996, *Journal of Metals*). The result of a survey of 125 companies and non-profit organizations participating in ATP projects was presented. According to the survey, 70 percent of the companies interviewed reported that there was little or no chance they would have pursued the technology now under development had they not received support through the ATP. Of the balance, 90 percent reported that they would have pursued goals at a much slower pace without government funding.

8. On page 466 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Aluminum, it is also stated: "Pilot-scale tests and economic analysis demonstrated the technical, economic and environmental viability of Aluminum Salt-Cake Recycling technology to avoid 550,000 tons landfill annually and save 12 trillion BTU/yr."

Q298a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of the Aluminum Salt-Cake Recycling technology, including identification of the recipients of that DOE funding.

A298a. The recipient of the DOE funding has been Argonne National Laboratory.

Aluminum Salt-Cake Recycling Technology Funding
(In Thousands of $)

	Funding		
Fiscal Year	**DOE**	**Private Sector**	**Total**
1991	100	50	150
1992	0	0	0
1993	400	50	450
1994	700	100	800
1995	1,149	850	1,999
1996	474	300	774
Total	2,823	1,350	4,173

Q298b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A298b. One patent is held by University of Chicago. More patents are expected soon.

Q298c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A298c. There is no provision for the DOE to receive royalties, since funding does not come from the Metals Initiative. Any patent royalties will be paid to Argonne National Laboratory.

Q298d. Please provide detailed documentation of the claim that "Pilot-scale tests and economic analysis demonstrated the technical, economic and environmental viability of Aluminum Salt-Cake Recycling technology to avoid 550,000 tons landfill annually and save 12 trillion BTU/yr."

A298d. In a paper by the Argonne researchers, "The Economics of Salt Cake Recycling, (*Light Metals 1996*, pp. 1255-1260) it is stated that electrodialysis is the most cost-effective technology to recover salts from salt cake brines, based on preliminary economic analysis. The paper compares 4 processes: base case (conventional technology), solvent-antisolvent precipitation of salts, high-temperature high pressure leaching of salt cake with partial flashing of the brine to recover the salts, and electrodialysis. Economic analyses indicate that a price of $0.055 per pound for the non-metallic product (NMP) is required for break even operation based on a 20% rate of return. Pilot-scale work with Alumitech has shown that this is possible. Therefore, salt cake constituents (aluminum, salt, NMP) are recycled/reused. A few minor engineering problems remain with electrodialysis. For example, salts have been precipitated from salt cake brine, but the solid salt crystals have not been recovered from the saturated brine solution.

Based on more recent analysis and data the 550,000 tons number has been revised to 800,000 tons. The 12 trillion Btu/yr number has been revised to 19.3 trillion Btu/yr.

Q298e. Please document why this technology would not have been developed in the absence of DOE funding.

A298e. The aluminum industry, especially the secondary aluminum industry has limited research capability. There is high risk in developing the technology relative to the alternative of paying for disposal of salt cake in landfills.

DOE funding supplemented with significant cost-share was judged necessary to spur development of this technology. See documentation for #283c. Similar documentation for the U.S. Department of Commerce's Advanced Technology Program (ATP) has been reported (April, 1996, *Journal of Metals*). The result of a survey of 125 companies and non-profit organizations participating in ATP projects was presented. According to the survey, 70 percent of the companies interviewed reported that there was little or no chance they would have pursued the technology now under development had they not received support through the ATP. Of the balance, 90 percent reported that they would have pursued goals at a much slower pace without government funding.

Q299. On page 466 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Metalcasting, it is stated: "The Metalcasting R&D program has developed a mathematical model of the cupola melting furnace. The American Foundrymen's Society is making this available to the Metalcasting industry for analyzing their own operations. This model provides the base for an intelligent control system which is currently under development. An eighteen inch cupola is being built to test this model. This control system will have application in foundries throughout the USA."

Q299a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of the mathematical model of the cupola melting furnace and eighteen inch cupola, including identification of the recipients of that DOE funding.

A299a. From 1989 to 1993, the recipient was the American Foundrymen's Society. The 1994 and 1995 recipients were Idaho State University, the Idaho National Engineering Laboratory, and the Albany Research Center (formerly administered by the Bureau of Mines).

Mathematical Model of the Cupola Melting Furnace and Eighteen Inch Cupola Funding (In Thousands of $)

Fiscal Year	**Funding**		
	DOE	**Private Sector**	**Total**
1989	186	198	384
1990	254	325	579
1991	221	317	538
1992	0	0	0
1993	85.43	293.23	378.66
1994	633	960.5	1,593.50
1995	92	300	392
Total	1,471.43	2,393.73	3,865.16

Q299b. What is the patent/license situation with regard to this model, i.e., who holds the patent(s)/license(s)?

A299b. Per standard practice for non-profit and educational institutions, the patent rights are assigned to the recipients and DOE retains a non-exclusive, nontransferable. irrevocable fully paid license and march-in-rights.

Q299c. Has (is) DOE receiving any royalties as a result of its role as a funder of this model, or will it in the future, and if not, why not?

A299c. DOE has not and does not expect to receive any royalty income from this project. PL 101-425, which established the Metal Casting Initiative, under Sec. 9 (c) Patent Rights states that the recipients shall be treated in the same manner as are non-profit organizations and small business firms under Chapter 18 of Title 35 United States Code. The royalty income after expenses and sharing with the inventor will be retained by the university and used for the support of scientific research and education.

Q299d. Please document why this model would not have been developed in the absence of DOE funding.

A299d. The U.S. Metalcasting industry is composed of approximately 3,000 foundries with the average foundry having around 70 employees. The individual operation cannot afford to do this research and, although the American Foundrymen's Society has contributed a very large cost-share to this project, they cannot afford to cover all of the cost of the research effort either. The cupola typically operates at about a 35% energy efficiency level and approximately 70% of the cast iron is produced in cupolas (14 million tons).

Q300. On page 466 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Metalcasting, it is also stated: "Design and processing technology to increase die life for metal casting has been developed which incorporates measured physical and metallurgical data for H-13 steel; and an expert system computer model to obtain improved microstructure and distortion control during heat treatment. Annual saving for the die casting industry of over $200,000 with a modest 20 percent increase in die life is expected. Die life extension is identified as technology critical to the metalcasting industry in meeting the needs of the automotive and transportation industry in general."

Q300a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this design and processing technology to increase die life for metal casting, including identification of the recipients of that DOE funding.

A300a. The information is provided in the following table. Dollars in parentheses are the costs for the Die Life Project. The fiscal year 1994 cost share for the Die Life Project is an estimation, since the cost share was not broken down by individua project. Ohio State University was the recipient of the funding and Case Western University performed the research as a subcontractor.

Funding (In Thousands of $)

Fiscal Year	Funding		
	DOE	Private Sector	Total
1994	419.126 (80.5)	471.566 (127.2)	890.692 (207.
1996	80.500	127.2	207.
Total	**499.626 (80.5)**	**598.766 (127.2)**	**1,098.392 (207.**

Q300b. What is the patent/license situation with regard to this technology, i.e., wh holds the patent(s)/license(s)?

A300b. Per standard practice for non-profit and educational institutions, the patent right are assigned to the recipients and DOE retains a non-exclusive, nontransferable irrevocable fully paid license and march-in-rights.

Q300c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A300c. DOE has not and does not expect to receive any royalty income from this project. PL101-425, which established the Metal Casting Initiative under Sec. 9 (c) Patent Rights, states that the recipients shall be treated in the same manner as are non-profit organizations and small business firms under Chapter 18 of Title 35 United States Code. The royalty income after expenses and sharing with the inventor will be retained by the university and used for the support of scientific research and education.

Q300d. Please provide detailed documentation of the claim that "Annual saving for the die casting industry of over $200,000 with a modest 20 percent increase in die life is expected."

A300d. Present die casting sales in the U.S. are approximately $6 billion. About 10 percent of the cost of the die casting is for the dies, so the present die cost is approximately $600 million. A 20 percent increase in die life would generate approximately $12 million in annual savings.

Q300e. Please document why this technology would not have been developed in the absence of DOE funding.

A300e. There are approximately 1,200 die casting plants in the U.S. The average plant has about 70 employees. These small plants have to cope with high capital costs and a limited engineering staff and still utilize a sophisticated and technologically demanding process. Moreover, they have to compete with foreign firms in an increasingly global economy. Development of better dies is an undertaking that no single plant will assume. Only by a joint effort with support from federal sources such as the DOE Metal Casting Research Program can such an issue be addressed.

01. On page 466 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Glass, it is stated: "Accoutre International, in cooperation with Corning, Anchor, Owens-Corning, Libbcy-Owens-Ford, Idaho National Laboratory, Clemson, and several other industrial partners, developed a temperature sensor able to withstand the thermal shock and corrosive atmosphere of molten glass to provide reliable, accurate information over the lifetime of a furnace. Its enhanced abilities will improve the quality of glass products and reduce energy consumption and emissions by optimizing the melting temperatures needed to produce glass."

Q301a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this temperature sensor, including identification of the recipients of that DOE funding.

A301a. During FY 1995, DOE provided $250,000 to AccuTru International for the development of an advanced temperature sensor suitable for the glass industry. There was no prior funding and no other funding is planned. AccuTru is investing

$150,000 of its funds in the project. The glass companies identified above are contributing another $225,000 to the project.

Q301b. What is the patent/license situation with regard to this technology, i.e., wh holds the patent(s)/license(s)?

A301b. Pursuant to 35 U.S.C. 202(a), AccuTru International will hold any patents that resul from the development of the sensor. Their intention is to commercialize the senso after the DOE phase of the project is completed. The licensing agreements woul be negotiated by AccuTru at that time.

Q301c. Has (is) DOE receiving any royalties as a result of its role as a funder of thi technology, or will it in the future, and if not, why not?

A301c. Since 35USC 202(a) does not provide for the government obtaining royalties, DO is not now and will not receive royalties from the sale of the temperature sensor DOE policy is to work with industry in developing technology that will improve energy efficiency and reduce the generation of waste. This is a high risk project tha could possibly be of great value to the glass industry. The DOE funding partiall "bought down" the financial risk to the industrial partners.

Q301d. Please document why this technology would not have been developed in th absence of DOE funding.

A301d. The glass industry is one of the oldest industries in the United States. Measuring th temperature of molten glass has always been an endemic problem throughout th industry. In the absence of DOE funding, the problem has never been solved Working within DOE's "Industries of the Future" program, AccuTru was able t form a consortium of glass industry partners and get valuable technical assistanc from two of DOE's National Laboratories. DOE thus was responsible for not onl providing 40% of the funding for this project, but also added technical capability.

Q302. On page 467 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, th Specific Accomplishments for Chemicals, it is stated: "The Boeing Company an Los Alamos National Laboratory received the prestigious recognition for a polyme membrane system to separate and recycle metals from spent electroplating solutions Besides the landfill problems caused by metal wastes in electroplating baths (an the regulatory pressures to eliminate the problems), the energy used to mine an purify the metals is wasted. Thousand of jobs are expected to be saved by th separation technology, as small business parts suppliers to the aerospace industr cannot afford expensive technology to treat electroplating wastes to mee regulations. The technology may find applications in other industries, such as meta processing and petroleum refining. Potential savings for the electroplating industr alone amount to 0.01 quadrillion BTUs and ten thousand tons of metal per year."

Q302a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this separation technology, including identification of the recipients of that DOE funding.

A302a. Work on this project is being supported by funds from The Boeing Company and funds from the DOE Industrial Waste Reduction Program (IWRP). Boeing will fund their own development and implementation work which is outlined in their letter of intent. Since Boeing has declined to enter into a CRADA agreement for legal reasons, work will be performed under a Field Work Proposal. The expected total of Boeing funding will more than match that provided by the IWRP funded portion of the program. Funds to support the LANL effort would come from the Office of Industrial Technology - DOE and would total $2,310,000 over the life of the program. Estimated IWRP expenditures are FY94-$550,000, FY95-$600,000, and FY96-$300,000 for the total effort proposed in the workplan.

(In Thousands of $)

Participants	FY91	FY92	FY93	FY94	FY95	FY96	FY97
DOE (to LANL)	275	215	520	550	550	380	
Boeing	275	215	520	550	550	380	
Total	**550**	**430**	**1,040**	**1,100**	**1,100**	**760**	

LANL support of this project is in the form of equipment, expertise in plating operations and in personnel who are knowledgeable in the area of metal-ion recovery and separations. This project is being leveraged from existing projects in transition metal chemistry and actinide/lanthanide separations (e.g., LDRD programs). Expertise and equipment obtained under DP and EM funded projects will be used for this project. Only indirect funds are coming into the project from other DOE sites at this time (e.g., RFP, INEL).

Q302b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A302b. The following patents applications have been filed:

1. "Water-Soluble Polymers For The Recovery Of Metal Ions From Aqueous Solutions," Barbara F. Smith, Thomas W. Robison. DOE No. S-78,353. Filed May 30, 1995.

2. "Process For The Displacement Of Cyanide Ions From Metal-Cyanide Complexes," Barbara F. Smith, Thomas W. Robison. DOE No. S-78,352. Filed May 30, 1995.

3. "Water-Soluble Polymers and Compositions Thereof" Barbara F. Smith, Thomas W. Robison, Joel Ghodes. DOE No. S-78.350. Filed May 30,1995.

4. "Water-Soluble Polymers For The Recovery of Metals From Solids." Barbara F. Smith, Thomas w. Robison, Nancy N. Sauer, Deborah Ehler. DOE No. S-78,351. Filed May 30, 1995.

The following licenses have been issued:

1. MicroSet for electroplating field of use.

2. Academy Corp. for precious metals in jewelry and photographic waste streams.

Q302c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A302c. DOE will not be receiving any license income as the title to these inventions reside with the University of California, pursuant to 35USC 202(a).

Q302d. Please provide detailed documentation of the claim that "Thousand of jobs are expected to be saved by the separation technology. . ."

A302d. Both the DOE complex and commercial sector metal finishing operations currently generate large quantities of toxic metal wastes that are converted to hydroxide sludges and sent for disposal. Metal finishing includes a variety of processes, including electroplating, plating, polishing, anodizing, and coloring. These processes are performed both by independent "job shops" and as captive operations by a wide variety of manufacturers. There are an estimated 3,500 independent metal finishing firms, more than two thirds of which employ less than 20 people, and estimated 10,000 captive metal finishing operations.

This project improves industrial competitiveness for the electroplating industry by minimizing metal losses from the electroplating processes to waste sludges, industrial liability is reduced, energy savings is realized, and ultimately, an economic saving should be realized. For these reasons, this technology will save and produce jobs.

Q302e. Please provide detailed documentation of the claim that "Potential savings for the electroplating industry alone amount to 0.01 quadrillion BTUs and ten thousand tons of metal per year."

A302e. Energy Savings: Energy is saved in at least three places if the metal in electroplating baths is recycled: (1) the energy involved in transporting the hazardous waste to a licensed disposal site, (2) the energy required to produce the metals that were discarded, and (3) the energy required to replace the waste water that is discarded. For this analysis, only the energy saved in metal production will be used. The energy savings which would result because metals are not discarded as waste (mining, processing, transport) would be 2.4x 10^{13} Btu/year total. Estimates of the savings due to the amount of water required by the plant, the energy involved in transport of the waste, and the energy involved in the processing of the waste water were not estimated. Estimates of the energy requirements for Superfund Site cleanup of toxic metal dump sites have not been made, but could be assumed to be close to the original costs of mining the metals. Thus, these estimates represent the lower limit on the energy savings that are obtainable. All of the Btu estimates are based on reasonable assumptions about technology diffusion throughout industry and technology application to more than one process, and will be revised as additional information becomes available.

Energy Use (Btu/year/unit)	**Current Technology**	**Proposed Technology**	**Annual Energy Savings in Year 2010 (Btu Total)**
Oil	0.11×10^9 Btu/yr/unit		0.2×10^{12} Btu Total
Natural Gas	0.55×10^9 Btu/yr/unit		1.2×10^{12} Btu Total
Coal			
Electricity (@ 10,500 Rtu/kWh)	8.2×10^9 Btu/yr/unit	0.8×10^9 Btu/yr/unit	18×10^{12} Btu Total
Distillate	4.6×10^8 Btu/yr/unit	0.2×10^9 Btu/yr/unit	4.1×10^{12} Btu Total

Note: Energy savings are based on 2,440 units and overall savings in 2010.

Waste Reduction: Recycling metals in the electroplating process reduces the amount of waste water that must be treated to remove heavy metals. The waste water treatment produces a sludge that must be disposed of in a hazardous landfill. In addition to a reduction in the amount of hazardous sludge that is produced, metal and water that would be discarded is saved.

A typical electroplating shop is estimated to produce 55,000 gallons per day of waste water in normal rinse operations (see table below). Also, four baths containing 500 gallons each of electroplating solution are assumed to be dumped each year in an average plating shop. Assuming an average concentration of heavy metals in this waste water of 300 ppm and 24 oz of metal per gallon in the discarded bath solution, about 18.5 tons of metal are discarded each year by a typical electroplating shop. If this discarded metal is entrained in a sludge containing about 20% by weight of heavy metal, a typical electroplating shop will produce 92.5 tons of sludge per year. If 90% of the metal could be recycled, the metal loss for a typical shop would drop to 1.8 tons per year and the sludge production would drop to 9.3 tons per year.

The waste is typically packaged in 55-gallon drums for shipment to the landfill. If each drum holds approximately 440 lb. of waste, 420 drums of hazardous waste will be shipped to the landfill compared with 42 drums for a shop using recycle.

Thus, installation of a recycling system will reduce the metal lost from a typical electroplating shop by 16.6 tons per year, and reduce the hazardous waste produced by 83 tons per year, and reduce the number of drums of hazardous waste shipped to a landfill by 380 drums per year.

If 20% of the projected 12,200 electroplating shops in the year 2010 use recycling, then approximately 140×10^6 tons of waste water would be eliminated. This would reduce the total heavy metal sludge production by 200,000 tons per year, resulting in a decrease of 925,00 drums of hazardous waste that must be disposed of in a hazardous materials landfill per year. Also, 40,000 tons of metal would be recovered each year and the waste waters can be recycled.

Waste Description	Current Technology	Proposed Technology	Annual Waste Reduction in Year 2010 (Tons Total)
Hazardous Sludge	92.5 ton/yr/unit	9.3 ton/yr/unit	1.6×10^4 ton/yr total
Waste Water	5.7×10^5 ton/yr/unit	5.7×10^4 ton/yr/unit	1.4×10^9 ton/yr total
Heavy Metal	18.5 ton/yr/unit	1.85 ton/yr/unit	4.1×10^4 ton/yr total

Note: Waste reduction is based on 2,440 units and overall reduction in 2010.

Q302f. Please document why this technology would not have been developed in the absence of DOE funding.

A302f. Boeing does not have the research capital, facilities, and expertise to perform the type of research work proposed. If this work is not pursued with Boeing, who is a leading plating facility and contractor to over 3,500 small plating shops, it is unlikely that a concerted recycle program for plating metals will be implemented in the near future. This could have grave consequences now that landban policies for burial of toxic metal ions have gone into effect. Because of Boeing's position and influence with a large number of smaller shops, they have an opportunity to rapidly transfer and implement this technology. Thus, this program provides a route for maximum leverage of government funds.

Q303. On page 468 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Petroleum Refining, it is stated: "The development of polyphosphazene membranes is intended to replace traditional distillation columns which are very energy intensive. Membrane systems which can survive harsh chemical environments will result in significant energy savings, make the US industry more competitive, and reduce wastes. For the targeted liquid to liquid separations, the potential energy savings is 0.067 trillion BTUs/unit-year, which translates to 0.2 quadrillion BTUs/year for 3,000 units, with full market penetration in the year 2020."

Q303a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding of this technology, including identification of the recipients of that DOE funding.

A303a. The following table lists the fundings in each fiscal year beginning in FY 1988, with INEL as the sole DOE funding recipient, cost-shared by the industrial partners:

BUDGET (In Thousands of $)									
PROJECT NAME: Polyphosphazene Membranes for Chemical Separations									
Fiscal Year	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
DOE	290	300	310	0	200	212	362	500	400
Industry	0	0	0	0	0	300	300	300	300
Total	290	300	310	0	200	512	662	800	700

Q303b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A303b. To date, there were three patents issued to INEL's polyphosphazene technology: One was issued to DOE; two were issued to Lockheed Idaho Technologies Company, the managing contractor of INEL.

Q303c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A303c. As of today, the Department has not received any royalties, but may in the next couple of years as the membrane materials and systems are commercialized.

Q303d. Please provide detailed documentation of the claim that "For the targeted liquid to liquid separations, the potential energy savings is 0.067 trillion BTUs/unit-year."

A303d. The following is the up-to-date documentation of the potential energy benefits of the polyphosphazene membranes:

Membranes in General: A DOE report (*Membrane Separation Systems: A Research Needs Assessment Executive Summary, DOE/ER/30133-H1, Vol. 1, pp 1-1, 1-2, April, 1990*) states that. "Improving the energy efficiency of production technology can lead to increased productivity and enhanced competitiveness of U.S. products in world markets. Processes that use energy inefficiently are also significant sources of environmental pollution." The report further states that "The rationale for seeking innovative energy-saving technologies is, therefore, very clear. One such technology is **membrane separation**, which offers significant reductions in energy consumption in comparison with thermal separation techniques." Conventional chemical separations such as distillation or evaporation require a change of phase, which is very energy intensive. It has been shown that the major process industries use in excess of 2 quads of energy per year for chemical separations and waste discharge. It is estimated that 20% of this energy could be saved by the turn of the century using membrane technology, if suitable membrane materials and processes were available.

INEL/Polyphosphazene Membranes. Over the years new polymers have been produced and the techniques have been developed to incorporate these materials into polyphosphazene membrane modules for chemical separations. Presently, our industrial partners have interests in three applications: (1) dehydration of organic liquids, (2) alcohol/dye separations as a model of an industrial process of interest, and (3) organics from water separations.

U.S. industry consumes an estimated 22.3 quads/yr of energy. The energy-intensive chemical and petroleum industries consume 5.8 quads/yr or 22% of the total. Within these industries, 2.52 quads/yr are required by separation processes, of which 95% is performed by distillation (*J. Humphrey, et al. DOE/ID/12920-1*). The INEL developed membranes could save substantial energy in water separations which now utilize distillation. Consider three separations that are potential applications for the polyphosphazene membrane systems. It has been estimated that distillation separations of water from oxygenated hydrocarbons consume 0.10 quads of energy per year. Separation by distillation of water from inorganics requires 0.06 quads of energy per year. The distillation of water from hydrocarbons uses 0.01 quads of energy per year. These three activities total 0.17 quads/yr of energy. Applications in about 20% of these areas have been identified for polyphosphazene membranes. Assuming that economics will drive most of these applications to be hybrid distillation/membrane processes, energy savings will amount to 40% of the current process energy, or 0.014 quads/yr.

Market Penetration: The North American membrane equipment market (1991) was $240 million, and in the world it was $445 million. Membrane modules typically make up 20-25% of the total system cost. The breakdown by technology shows the market growth potential of membrane (pervaporation) systems (data from Media & Process Technology, Inc.; H.L. Fleming 1992).

The following estimates are based upon a total potential market of 3000 units in the year 2010. Five units would begin operation in 1998 and a 20% market share would translate into 592 units in the year 2010. Conservatively assuming no growth in the chemical industry market would lead to 300 units operating in 2015.

Technology	**Market Size ($MM)**		
	North America	**Europe**	**Asia**
Total Dehydration Equipment	240	130	75
Distillation	160	90	56
Adsorption	55	10	56
Absorption	8	4	3
Pervaporation	5	17	8
Miscellaneous	12	9	2
Annual Growth Rate (%)	8	10	12
Membrane (PV) Growth Rate (%)	35	40	40

Market Penetration:

Hurdle rate IRR (%)	25%
Year of Introduction (with combined lab funding and industrial partner support)	1998
Number of Units at Introduction	5
Total Potential Market at Introduction (# Units) in 2010	3,000
Number of Units in Operation in 2010	592
Growth Rate of Total Potential Market (annual)*	0%
Maximum Market Penetration (fraction)	0.20
Number of Years at Market Saturation	20

* Assumed that chemical industry has few new plant start-ups with the majority of market potential based upon existing plant retrofitting. Therefore this is a conservative estimate because typical market growth during the past twenty years has conservatively been 3 to 5%.

Energy Benefits Calculations: Substantial energy savings and waste cleanup/reductions are possible with membrane systems. The INEL technology is scaling up to a pallet sized system in order to generate data that can be used to define its capabilities and performance. The data that is generated can then be used to develop quantitative energy and waste calculations for each membrane type related to a specific application.

The following two tables give the energy savings of membrane systems based upon the market penetration figures given in the previous section. The per unit savings are typical of membrane systems in operation (*Pervaporation Membrane Separation Processes, Huang, Ed., Elsevier, NY, 1991, Chapter 9*).

Energy Savings:

A	**B**	**C**	**D=B-C**	**E**	**F=DxE**
Description	**Conventional Technology (10^{12} Btus/ yr/unit)**	**New Technology (10^{12} Btus/yr/ unit)**	**Energy savings per unit, current less proposed (10^{12} Btus/yr)**	**Number of proposed units operating in 2010**	**Energy Savings in Year 2010 (10^{12} Btus/yr)**
Distillate Oil	0.028	0.017	0.011	592	6.5
Natural Gas	0.138	0.083	0.055	592	32.6
TOTAL	**0.166**	**0.100**	**0.066**	**592**	**39.1**

Source: Energy Information Administration, Monthly Energy Review, April 1995; Energetics, Inc. Estimates.

Total Yearly Energy Savings:

		Energy Savings by Fuel Type (million Btus)		Total Energy Savings	
Year	**Number of Units in Operation**	**Distillate Oil**	**Natural Gas**	**Million Btus**	**1994$**
1998	5	55,000	273,500	328,000	1,036,160
2000	79	869,000	4,321,300	5,190,300	16,371,328
2005	464	5,104,000	25,380,800	30,484,800	96,155,648
2010	592	6,512,000	32,382,400	38,894,400	122,681,344
2015	600	6,600,000	32,820,000	39,420,800	124,339,200
2020	600	6,600,000	32,820,000	39,420,800	124,339,200
2025	600	6,600,000	32,820,000	39,420,800	124,339,200

Q303e. Please document why this technology would not have been developed in the absence of DOE funding.

A303e. There are three reasons why the Department gets involved in developing and commercializing this technology:

1. Membranes are an emerging technology. The membrane polymers have a great potential for wide applications that can achieve tremendous energy and cost savings for the chemical and petrochemical industries.

2. Unique R&D capability exists at the Idaho National Engineering Laboratory (INEL) with this unique polymer material.

3. Due to its high risk and generic nature, this technology is not mature enough for development by the private sector alone. Government support at this point is essential to any success that result from the use of this membrane technology.

Q304. On pages 468 and 469 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, the Specific Accomplishments for Petroleum Refining, it is stated: "Zeolites, known as molecular sieves, are a class of catalytic materials that play a crucial role in the petroleum refining, petroleum and commodity chemicals industries in the United States. Zeolites are the high-activity component used in cracking catalysts, and over one-third of the crude oil refined in this country passes through a fluidized catalytic cracking process using zeolites. Los Alamos National Laboratory and Lawrence Berkeley National Laboratory, along with Chevron, W.R. Grace, Mobile, Arco Chemicals, Catalytica, and Biosym Technologies are developing models and characterizing the active acid sites of zeolite catalysts to manufacture zeolite catalysts with a goal of 1% improvement compared to current zeolite catalysts. A 1% improvement in the development of zeolite catalysts would result in over 6 trillion Btus in energy savings. Improved zeolite catalysts also could result in decreased spent catalysts and reduced emissions. With the expectation of achieving a 1% improvement, W.R. Grace in FY 1995 signed a CRADA that will allow the findings by Los Alamos National Laboratory to be incorporated into their process for developing industrial catalysts for fluid catalytic crackers for proof testing."

Q304a. Please provide, by fiscal year, from date of initiation to present, both DOE and private-sector funding, including identification of the recipients of that DOE funding.

A304a. The modeling research efforts with Los Alamos and Lawrence Berkeley National Laboratories were initiated in FY 1990. There are four phases to the research effort: Phase I-Model Development (FY 1990-FY1993), Phase II-Model Validation (FY 1992-FY 1996), Phase III-Model Application (FY 1995-FY 2000), and Phase IV-Model Commercialization (FY 1998 ---). The research effort at Los Alamos is in Phase II and the research effort at Lawrence Berkeley is in Phase III. The funding profile by fiscal year follows (in thousands of $):

National Laboratory	FY90	FY91	FY92	FY93	FY94	FY95	FY96
Los Alamos	250	250	825	750	650	438	100
Lawrence Berkeley	250	250	250	190	250	225	75
Total	**500**	**500**	**1,075**	**940**	**900**	**963**	**175**

There were no Federal funds provided to the industry partners identified above (i.e., Chevron, W.R. Grace, Mobile, Arco Chemicals, Catalytica, and Biosym Technologies) through their collaboration with Los Alamos and Lawrence Berkeley. These industry partners did, however, provide cost-sharing in support of the National Laboratory R&D efforts. The cost-sharing attributed to the National Laboratories in support of this research is shown below:

Cost-Sharing Totals from Industry According to National Laboratory
(In thousands of $)

National Laboratory	FY90	FY91	FY92	FY93	FY94	FY95	FY96
Los Alamos	0	90	156	590	540	238	0
Lawrence Berkeley	0	434	200	218	130	312	0

Q304b. What is the patent/license situation with regard to this technology, i.e., who holds the patent(s)/license(s)?

A304b. The research in question involves the development of models to describe and explain the activity of zeolite catalysts. There are two models involved, one from Los Alamos (a reaction transition state model) and the other from Lawrence Berkeley (a mass transport model). All intellectual property related to these models reside with the National Laboratory through the respective Management & Operation contractor. At this time, there are no patents or licenses associated with these two models.

Q304c. Has (is) DOE receiving any royalties as a result of its role as a funder of this technology, or will it in the future, and if not, why not?

A304c. DOE is not receiving royalties from the models developed at the Los Alamos and Lawrence Berkeley National Laboratories. The models in question are experimental and exploratory and have not progressed beyond the "laboratory" stage of use or development.

Q304d. Please provide detailed documentation of the claim that "A 1% improvement in the development of zeolite catalysts would result in over 6 trillion Btus in energy savings."

A304d. This Btu savings figure is based on a study conducted by the Pacific Northwest National Laboratory. Three reports were generated from this study: *Brief Characterizations of the Top 50 U.S. Commodity Chemicals, Characterizations of the Top 12 U.S. Commodity Polymers, and The Top 50 Commodity Chemicals: Impact of Catalytic Process Limitations on Energy, Environment. and Economics.* These reports provide extensive information, such as energy use, waste production, economic impact. etc, on the key chemical processes within the U.S. petrochemical industry. The processes that use zeolite catalysts are specifically identified in the reports. Using the process information generated, the study conducted analyses assuming various levels of process chemistry and process engineering improvements, including improvements in the catalyst performance. The 1% improvement identified above is the least optimistic of the process improvement scenarios examined. Details of the analyses are provided in the report *The Top 50 Commodity Chemicals: Impact of Catalytic Process Limitations on Energy, Environment. and Economics*, which also includes two disks containing Excel spreadsheets of the analyses.

Q304e. Please document why this technology would not have been developed in the absence of DOE funding.

A304e. This research effort falls into the category of enabling technologies. The development of these models as per the research objectives identified and the applicability of these models in manner envisioned were not previously known. This is a risk that industry, in general, will not assume. In view of the research objectives identified, Los Alamos and Lawrence Berkeley National Laboratories were the more capable sources of the computational and computer-code development expertise required to undertake the research. The primary focus of the research was on the development of the models, inclusive of the computer codes. Corporate involvement was necessary to determine the capability, accuracy, and usefulness of the models based on corporate process operation experience. The companies identified above, Chevron, W.R. Grace, Mobile, Arco Chemicals, Catalytica, and Biosym Technologies are early pioneers in testing the capabilities of the models. They do not have exclusive use or access to these models. (As a side note, this research effort was conducted in collaboration with the basic sciences divisions of DOE. This collaboration provided the code development capabilities and some computation time required to develop the models.)

Zeolite catalysts are used extensively throughout the petroleum and chemical industries. They are not a one company product line. In a similar manner, these models are not in the sole possession of any one company and are equally available to any petroleum or chemical company that has the need to evaluate opportunities to improve its process operations. Whereas the models themselves will not produce the energy savings, waste reductions, or economic improvements identified in the three Pacific Northwest National Laboratory's reports, the models offer the opportunity for industry to identify the more productive areas to direct its research toward energy savings, waste reduction, and economic improvements. This is not a one company directed need or capability, but a need or capability shared throughout the industry, and by companies looking to improve profits through improved catalyst efficiency. The Pacific Northwest National Laboratory's reports showed that higher profits are achievable through increased catalyst efficiencies associated with improvements in process chemistry and engineering.

Q305. Page 470 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Industries of the Future (Specific) Textile Partnership:

	2000	2010	2020
Energy Savings (quad/year)	**0.05**	**0.2**	**0.3**
Cost Savings ($M/year)	**10**	**20**	**30**
Carbon Reduction (M ton/year)	**1**	**3**	**6**

Q305a. Please provide detailed documentation of these claimed benefits.

A305a. These are *conservative* estimates, based on industry analysis of the benefits of a successful AMTEX partnership between the DOE and the U.S. textile industry.

The primary contribution to the reported savings arises from the central activity within AMTEX: the *Demand Activated Manufacturing Architecture (DAMA)* project. DAMA will provide the textile industry with tools and techniques to integrate the entire industry–from fibers to consumer products–through an "electronic marketplace" for suppliers and customers.

At present, the "lead time" to bring raw fibers to a finished textile product–the time it takes to take mature cotton from a field through the manufacturing steps to a cotton shirt, for example–approaches a year. It is estimated that nearly two-thirds of this time is lost due to inefficiencies in the "textile supply chain." Associated with the lost time, of course, is lost money–and wasted energy as well. Industry sources estimate the total losses to the industry due to inefficiencies in management of the supply chain as about $20 billion. DAMA's goal is to reduce the "lead time" from a year to three or four months (in the case of shirts, for example. These times vary with specific products.)

At minimum, DAMA will provide textile businesses with at least one widely accepted tool to manage their inventories by integrating more effectively with their customers and their suppliers. This single business tool (an "electronic commerce" tool) would save the industry at least one half of a percent of their total losses by the time a prototype tool was available in 2000–or $10 million.

The energy savings that accompany the money saved from better inventory management result from saved transportation, reduced manufactured product storage time, and manufacturing only wanted products. The total energy savings associated with saving the $10M is estimated as 0.05 Q/year.

Carbon emission reductions result from increasing the textile manufacturing supply chain efficiency, and also from the introduction of new, energy efficient and pollution prevention technologies in the industry. Within the AMTEX partnership, these technologies are under development by DOE labs in concert with the textile industry and their equipment suppliers for nearly all phases of textile goods manufacture. Example activities within the AMTEX *Textile Resource Conservation (TReC)* project include technologies to completely recycle process water in textile plants; technologies to recover dyes and chemicals from process streams; and technologies to control air quality and humidity at textile plants. Conserving 10% of the chemicals used in textile manufacturing, and reducing by 5% the total fibers lost in manufacturing processes (which would otherwise be burned) amounts to a million tons of carbon emission reductions a year.

The reported estimates in energy, cost, and emissions savings assume that only 5% of the technologies under development within the AMTEX scope attain full market penetration and market acceptance at the height of their commercial lifetimes. This hypothetical commercial success rate is low compared with similar high-risk R&D programs demonstrating typical commercial success rates of 10-15%. The AMTEX investments will continue to pay large dividends in energy savings, cost savings, and emissions reductions long after the completion of the program, through technology spin-offs and energy technology development.

Q305b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A305b. Textile industry representatives have stated that they do not have the resources for R&D of the technologies that they need to bring about the stated benefits, and they have identified DOE, through its laboratory system, as having those resources. The textile industry comprises thousands of small businesses, operating under slim (often negligible) profit margins, and can not afford the cost of the technology R&D within AMTEX. Furthermore, the textile industry cannot afford the potential losses associated with the high-risk R&D assumed within AMTEX. The AMTEX partnership unifies textile industry R&D, and provides maximum benefits across the textile industry sector.

AMTEX will provide a “new industrial revolution” for the textile industry–at a time when the U.S. industry has faced the most severe challenges ever encountered by any industrial sector.

Q306. Please provide a listing of the recipients of (i) the $9,688,000 in funding in FY 1995, (ii) the $11,278,000 in FY 1996 funding, and (iii) the requested level of $13,140,000 in FY 1997 for the Forest and Paper Products Vision.

Q307. For each recipient of Forest and Paper Products Vision funding identified in the response to question 306 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A306 and A307. See the following table.

Forest Products Industry Projects– Recipients of Funding and Cost-Sharing

(In Thousands of $)

		Cost-Sharing		
Project Title	**Funding Recipient(s)**	**FY 95**	**FY96**	**FY97**
Corrosivity Monitoring of Kraft Recovery Boilers	Institute of Paper Science and Technology	156	80	149
Sulfur Free Pulping	National Renewable Energy Laboratory	0	0	0
Paper Mill Sludge Utilization	Biofine	1,291	222	63
Pulp Bleaching Waste Recycling	Ceramatec	284	116	641
Black Liquor Electrolysis	Osmotek	56	137	50
Polyoxometalate Bleaching	University of Wisconsin	137	0	105
Energy Efficient Kraft Pulping for Low Lignin	Auburn	123	86	104
Asym. Whirl Combustion	Princeton	100	0	0
Black Liquor (GA Tech)	Georgia Tech	100	0	0
Recovery Boiler Model	Institute of Paper Science and Technology	1,220	0	0
Impulse Drying	Institute of Paper Science and Technology	374	2,088	0
Pulse Gasifier	Manufacturing and Technology Conversion International (MTCI)	1,634	TBD	TBD
Transport Processes	Oak Ridge National Laboratory	0	0	0
High Solids Firing	Babcock and Wilcox	110	3	2,000
Black Liquor Properties	University of Florida	0	200	210
Adv. Techs for Biomass Energy Utilization	Princeton	109	0	0
TMP Model (IEA)	Institute of Paper Science and Technology	75	0	0
Ultrasonic Sensor for Paper Stiffness	Institute of Paper Science and Technology	1,362	1,140	733
Black Liquor Viscosity Sensor	University of Florida	106	0	0
Recovery Boiler-FTIR	Advanced Fuel Research	100	0	0
Refiner Disc Gap and Wear Meas. Model	Dynametrix	98	84	108
Impr. Removal of Light & Sticky Contaminants	Black Clawson	655	219	0
CORRIM II Consortium	University of Minnesota	0	54	0
VOC Control in Kraft Mills	Institute of Paper Science and Technology	0	158	403

Project Title	Funding Recipient(s)	Cost-Sharing		
		FY 95	FY96	FY97
Low-Temperature Oxidation of Volatile Organic Compounds	National Renewable Energy Laboratory	0	34	47
Low-VOC Drying of Lumber and Wood Panel Products	Institute of Paper Science and Technology	0	100	100
Coupled Physical/Chemical and Biofiltration Technologies	Michigan Technological University	0	75	38
Recycling of Bleach Plant Filtrates via Electrodialysis	Argonne National Laboratory	0	49	93
Control of Accumulation of Non-process Elements and Org. Cmpnds in Pulp Mills	Oregon State University	0	20	33
Photoactivated Ion Exchange Resins	National Renewable Energy Laboratory	0	26	49
High Efficiency ClQ Delignification	Institute of Paper Science and Technology	0	79	117
Biomass Gasification Combined Cycle	Pacific Northwest National Laboratory	0	558	1,622
Electrochemical and integrated Processes for Prod. of Chlorine Dioxide	Auburn University	0	25	25
Distributed Fiber Optic Sensing Sys. For 100% Meas. Of Paper Web Parameters	Lawrence Berkeley National Lab, Argonne National Lab, Pacific Northwest National Lab	0	111	225
CCD-Based Sensor Instrumentation for On-Line Measurements	Lawrence Berkeley National Lab, Lawrence Livermore National Lab, Idaho National Engineering Lab, Oak Ridge National Lab	0	108	225
Rapid Chemical and Physical Char. of Wood Chips and Paper	Ames Lab, National Renewable Energy Laboratory	0	45	108
Pulp and Chip Refining Sensor Technology	Idaho National Engineering Laboratory	0	38	150
TOTAL		**8,090**	**5,855 (+TBD)**	**7,398 (+TBD)**

Q308. For those Forest and Paper Products Vision funding recipients identified in the response to question 306 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A308. Most of the projects in the forest projects vision area have been awarded through a competitive solicitation and review process. A small number have been awarded through the acceptance of an unsolicited application for financial assistance. These financial assistance awards were made in accordance with the relevant regulations in 10 CFR 600 primarily on the basis of unique or exclusive capability. While issued as "noncompetitive awards," these proposals were critically reviewed by reviewers within the Department of Energy and their acceptance was based on overall merit, anticipated objectives, capabilities of the recipient, qualifications of key personnel, and contribution to the goals of OIT. These projects are: Osmotek, Inc., Black Liquor Electrolysis; Babcock & Wilcox, High

Solids Firing; University of Florida, Black Liquor Properties; Advanced Fuel Research, Recovery Boiler, FTIR.

Q309. On page 471 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for the Forest and Paper Products Vision, it is stated: "Benefits of the forest products vision activities to the nation include increased energy efficiency resulting in energy savings of 0.57 quadrillion BTUs/yr resulting in a cost savings of $2 billion, and reduced waste generation of 20 million tons/yr resulting in a cost savings of $24 million. . . Jobs saved or created by development of these advanced technologies exceed 12,600 person years in 2010."

Q309a. Please provide detailed documentation of the claim that "Benefits of the forest products vision activities to the nation include increased energy efficiency resulting in energy savings of 0.57 quadrillion BTUs/yr resulting in a cost savings of $2 billion. . .".

A309a. OIT is in the process of conducting detailed, project-level analysis of each project funded using a calculational modeling tool called the "OIT Project Benefit Analysis Worksheet" developed specifically for this purpose. The model calculates energy and related cost savings (versus the state-of-the-art existing technology) based on fuel type(s) used/displaced, sector-specific energy costs, size of market, market penetration rate, and other project-specific information. At the time the 1997 budget was prepared, about one-third of the projects in the Forest Products vision area had been analyzed using this model. The values cited from the 97 budget were obtained by extrapolation to the remaining two-thirds of the projects in proportion to their budgeted value.

All projects in the Forest Products vision areas will be analyzed using this model by the end of 996, which will produce a more accurate estimate of total anticipated energy and cost savings.

Q309b. Please provide detailed documentation of the claim that "Benefits of the forest products vision activities to the nation include . . . reduced waste generation of 20 million tons/yr resulting in a cost savings of $24 million. . .". Jobs saved or created by development of these advanced technologies exceed 12,600 person years in 2010."

A309b. OIT is in the process of conducting detailed project-level analysis of each project funded using a calculational modeling tool called the "OIT Project Benefit Analysis Worksheet" developed specifically for this purpose. The model calculates waste reduction (versus the state-of-the-art existing technology) for both combustion and non-combustion related emissions based on fuel type(s) used/displaced, fuel-specific emission factors, raw materials used/displaced/recycled, waste generation, size of market, market penetration rate, and other project-specific information. At the time the 1997 budget was prepared, about one-third of the projects in the Forest Products vision area had been analyzed using this model. These projects alone will save approximately 200 million tons of waste per year (note that the figure of 20 million tons/yr cited in the 97 budget is a misprint). All projects in the Forest

Products vision areas will be analyzed using this model by the end of 1996, which will produce a more accurate estimate of total anticipated waste reduction.

Q309c. Please provide detailed documentation of the claim that "Jobs saved or created by development of these advanced technologies exceed 12,600 person years in 2010."

A309c. This value is based on a 1993 study by Charles Teclaw entitled *Estimate of Returns on DOE Investments in the Industrial Waste Reduction Program (IWRP).* This study investigated the macroeconomic impacts of DOE investments in energy efficiency and waste reduction projects and estimated that 140 person years of cumulative employment are generated per $1 million of DOE investments in these programs. Using this figure, cumulative spending for projects in the forest products vision area through FY 2010 is estimated to generate approximately 12,600 person years of cumulative employment.

Q309d. Please document why these benefits would not be achieved in the absence of DOE funding.

A309d. In the absence of DOE funding, it is very likely that these projects would either not have been funded or been funded at a lower level. These projects reflect one or more of the following situations: the cost of R&D is too high for an individual company to recuperate; the risk of successful commercialization is too high; the anticipated benefits are difficult for an individual firm to capture; or the public benefit far outweighs the private benefit.

Q310. Please provide a listing of the recipients of (i) the $4,332,000 in funding in FY 1995, (ii) the $6,618,000 in FY 1996 funding, and (iii) the requested level of $10,060,000 in FY 1997 for the Steel Vision.

Q311. For each recipient of Steel Vision funding identified in the response to question 310 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A310 and A311. See the following table.

Steel Vision Industry Projects–
Recipients of Funding and Cost-Sharing
(In Thousands of $)

	Cost-Sharing		
Funding Recipient(s)	**FY 95**	**FY96**	**FY97**
American Iron and Steel Institute	824	1,347	1,000
Carnegie Mellon Research Institute	0	0	0
Argonne National Laboratory	0	0	0
Metal Recoveries Industries (U.S.) Inc.	1,700	1,500	1,900
Total	**2,524**	**2,847**	**2,900**

Q312. For those Steel Vision funding recipients identified in the response to question 310 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A312. AISI Process control: unsolicited proposal (AISI Process control project had a technology that had not previously been developed by any other industrial company.)

Argonne National Laboratory Electrochemical dezincing FWP: Argonne was awarded this work because of unique chemical process development expertise not available at other locations.

Q313. On page 474 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for the Steel Vision, it is stated: "Benefits of activities by the year 2010 include reductions in energy use in the steel industry of .1 quadrillion Btus per year, in energy use and emissions in the transportation industry from 0.9 billion gallons lowered fuel consumption per year. . ."

Q313a. Please provide detailed documentation of these claims.

A313a. See answer to 313b below.

Q313b. Please document why these benefits would not be achieved in the absence of DOE funding.

A313b. The energy savings of 0.1 quadrillion Btus per year for Steel Vision are based upon two factors: (a) a reduction in the energy required to produce hot metal from dezinced scrap rather than primary ore and (b) estimates of the market for this technology. The market penetration is estimated to be 4.5 million ton or less than one half of the galvanized scrap available by the year 2000. The energy conserved by this technology is based on 16 million Btu/ton now required to produce hot metal from primary ore. The dezincing technology will require 5 million Btu/ton to produce hot metal from clean scrap: (16 million Btu/ton-5 million But/ton) = 11 million Btu/ton savings x 4.5 million tons market potential = 49.5 trillion Btu.

Q314. Please provide a listing of the recipients of (i) the $3,690,000 in funding in FY 1995, (ii) the $1,414,000 in FY 1996 funding, and (iii) the requested level of $8,587,000 in FY 1997 for the Aluminum Vision.

Q315. For each recipient of Aluminum Vision funding identified in the response to question 314 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

Q316. For those Aluminum Vision funding recipients identified in the response to question 314 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A314, A315 and A316. See the following table.

Aluminum Vision Industry Projects– Recipients of Funding and Cost-Sharing

(In Thousands of $)

	Cost-Sharing			
Funding Recipient(s)	**FY 95**	**FY96**	**FY97**	**Award Bases/Justification**
Aluminum Company of America (Alcoa)	554	201	2,424	Competitive Solicitation
Argonne National Laboratory (ANL)	850	300	2,500	CRADA to National Laboratory with established expertise.
Oak Ridge National Laboratory (ORNL)	160	135	350	CRADA to National Laboratory with established expertise.
Dow Chemical Company	75	0	0	Competitive Solicitation
EMEC Consultants	160	0	0	Competitive Solicitation
Aluminum Vision Partners (TBD)	0	0	0	Competitive Solicitation
Total	**1,799**	**636**	**5,274 (+TBD)**	

Q317. On page 476 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for the Aluminum Vision, it is stated: "The projected benefits for this program by year 2010, assuming a conservative 2.5% annual market growth, include 0.41 Quads energy savings in primary aluminum production. The cost savings in metal production and fabrication will enable full utilization of aluminum in the transportation sector which will save an additional 0.9 Quads. Annual reduction in greenhouse emissions of 9 million tons from metal production and an additional 83 million tons will be realized from the full implementation of aluminum in light weight vehicles. 6000 jobs will be generated/saved through cost reductions in the aluminum production industry alone. Up to 30% production cost savings can be achieved for a $38 billion industry."

Q317a. Please provide detailed documentation of the claim that "The projected benefits for this program by year 2010, assuming a conservative 2.5% annual market growth, include 0.41 Quads energy savings in primary aluminum production."

A317a. The Aluminum Annual Review 1994 by Anthony Bird Associates projects 5% annual growth in aluminum consumption for the period from 1995 to 2001. Due to the predicted increase in aluminum recycling, they predict that primary aluminum will account for a declining share of the world consumption of aluminum. Based on these trends, a conservative 2.5% annual growth in primary aluminum production was used in the benefit calculations performed by Energetics Co. and the Pacific Northwest Laboratory. The base line energy saving for 1995 U.S. primary aluminum production was 0.26 Quads (cathode & anode 0.24, calciner 0.01, alumina sensor 0.01). Arthur D. Little Inc. has reviewed and concurred with their results.

Q317b. Please provide detailed documentation of the claim that "The cost savings in metal production and fabrication will enable full utilization of aluminum in the transportation sector which will save an additional 0.9 Quads."

A317b. The projected energy savings in the transportation sector was based on the use of 500 pounds of aluminum per auto, an average auto life of 100,000 miles or 7 years and a U.S. fleet of 100 million cars. The benefits reported were the result of aluminum program benefits analysis performed by Energetics Co. and the Pacific Northwest Laboratory. Arthur D. Little Inc. has reviewed and concurred with the results.

Q317c. Please provide detailed documentation of the claim that "Annual reduction in greenhouse emissions of 9 million tons from metal production and an additional 83 million tons will be realized from the full implementation of aluminum in light weight vehicles."

A317c. The annual reduction in greenhouse emissions from metal production is the result of eliminating the consumption of carbon anodes which generate ~ 1.3 pounds of CO_2 per pound of metal produced (4.9 million tons per year) and the reduction in power generation plant emissions (4.1 million tons per year) resulting from the 0.26 Quad energy saving (see 317a) through the use of the new low energy cell technology. The calculations assume ~60% of U.S. smelter power is hydro. The annual 0.9 Quad reduction in fuel consumption by light weight autos (see 317b) will reduce CO_2 emissions by the reported 83 million ton per year. Benefits reported were the result of aluminum program benefits analysis performed by Energetics Co. and the Pacific Northwest Laboratory. Arthur D. Little Inc. has reviewed and concurred with the results.

Q317d. Please provide detailed documentation of the claim that "6000 jobs will be generated/saved through cost reductions in the aluminum production industry alone."

A317d. It is estimated that the reduced energy, alumina and carbon anode fabrication costs will enable the re-opening of closed smelters and/or avoid the closure of marginal smelters in the U.S. Most smelters are located at remote locations were the smelter supports a major portion on the local business. It is estimated that the loss of 1,000 jobs in the closure of a typical smelter would result in the loss of an additional 1,000-2,000 jobs in the support industries. A conservative impact on jobs for a closure/re-opening of 2-3 smelters would impact 6,000 jobs.

Q317e. Please provide detailed documentation of the claim that "Up to 30% production cost savings can be achieved for a $38 billion industry."

A317e. It is estimated that the U.S. aluminum industry contributes over $300 billion to the U.S. Gross Domestic Product and that the aluminum energy conservation programs could reduce energy consumption in the production of primary aluminum of 2-3 smelters would impact 6,000 jobs. Arthur D. Little Inc. has reviewed and concurred with the projected energy savings.

Q318. Please provide a listing of the recipients of (i) the $2,958,000 in funding in FY 1995, (ii) the $1,945,000 in FY 1996 funding, and (iii) the requested level of $5,500,000 in FY 1997 for the Metal Casting Vision.

A318. **FY 1995 Funding Recipients:** Penn State University; Industrial Advisory Board; Worcester Polytechnic Institute; Ohio State University; BCS; Case Western Reserve University; University of Alabama-Tuscaloosa; University of Alabama-Birmingham; and Idaho National Engineering Laboratory.

FY 1996 Funding Recipients: Sandia National Laboratories; Idaho National Engineering Laboratory; BCS. The following are projects proposed for co-funding in FY 1996 with the Cast Metal Coalition. All Federal Funding of projects will be matched through non-federal in-kind or cash. Funding is proposed for: Ohio State University; University of Iowa; University of Missouri-Rolla; Purdue University; University of Alabama; Worcester Polytechnic Institute; Carnegie-Mellon; University of Toronto; University of Northern Iowa; CANMET/MTL; Case Western Reserve University; L.E. Griffith Associates; University of Tennessee; and Materials Properties Council.

FY 1997 Funding (proposed research): For FY 1997, approximately $5,000,000 will be obligated to SCRA for projects recommended for co-funding by the Cast Metal Coalition. Proposals will be provided by competitive solicitation. All projects will have direct linkage to the research needs identified in the metal casting industries vision of the future "Beyond 2000: A Vision for the American Metalcasting Industry" and the technology roadmaps being developed by the metal casting industry. The Federal funding of all projects will be matched through non-Federal in-kind or cash.

Q319. For each recipient of Metal Casting Vision funding identified in the response to question 318 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A319.

F Y 1995 Cost-Share

Recipient of Research Funds	Cost-Share
Penn State University	$242,938
Worcester Polytechnic Institute	291,644
Ohio State University	254,520
Ohio State University	215,520
Case Western Reserve University	260,236
University of Alabama-Tuscaloosa	198,014
University of Alabama-Birmingham	701,590
University of Alabama-Birmingham	230,000
Idaho National Engineering Laboratory	46,796
Total	$2,441,258

FY 1996 Cost Share
All Federal funding of projects will be matched through non-federal in-kind or cash.
(Proposed cost share will match proposed funding)

Total	$990,071

FY 1997 Cost Share
All Federal funding of projects will be matched through non-federal in-kind or cash.
(Proposed cost share will match proposed funding)

Total	$5,000,000

Q320. For those Metal Casting Vision funding recipients identified in the response to question 318 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A320. All projects for FY 1995 were selected competitively, including the support service contract to BCS. For FY 1996, the funding to SCRA was not competitively awarded. SCRA will coordinate the efforts of the Cast Metals Coalition to implement cost shared research and development that will benefit the metal casting industry. The Cast Metals Coalition consists of the American Foundrymen's Society, the North American Die Casting Association, and the Steel Founder's Society of America. The ultimate recipients of the funding will be selected competitively.

Q321. Please provide a listing of the recipients of (i) the $3,428,000 in funding in FY 1995, (ii) the $1,396,000 in FY 1996 funding, and (iii) the requested level of $5,182,000 in FY 1997 for the Glass Vision.

Q322. For each recipient of Glass Vision funding identified in the response to question 321 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A321 and A322. See the following table.

Glass Vision Industry Projects–
Recipients of Funding and Cost-Sharing
(In Thousands of $)

	Cost-Sharing		
Funding Recipient(s)	**FY 95**	**FY96**	**FY97**
Institute of Gas Technology	615	0	236
Corning Incorporated	1,267	0	0

	Cost-Sharing		
Funding Recipient(s)	**FY 95**	**FY96**	**FY97**
Los Alamos National Laboratory	250	796	797
Accutru International	250	0	0
Vortec	750	0	0
Schuller International	250	0	0
Idaho Field Operations Office	46	0	0
Oak Ridge National Laboratory	0	425	365
Sandia Livermore National Laboratories	0	175	0
Brigham Young University	0	0	401.8
University of New Hampshire	0	0	400
Total	3,428	1,396	2,199.8

Q323. For those Glass Vision funding recipients identified in the response to question 321 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A323. Los Alamos National Laboratory CRADA with Schuller International, Inc. for Development and Design of Intermetallic Materials; Oak Ridge National Laboratory to develop new alloys for glass furnace components using unique lab facilities; Oak Ridge National Laboratory to develop refractory needs with glass industry with projects pending; Oak Ridge National Laboratory CRADA with Osram Sylvania to develop gel casting technique for lighting industry; Los Alamos National Laboratory CRADA with 3M to develop continuous fiber ceramic oxide filament tows; Sandia National Laboratory CRADA with Libby-Owens-Ford to gain understanding and develop chemical vapor deposition. These projects are done in conjunction with the Advanced Industrial Materials and Combustion Programs, which provide funding only to national laboratories and universities to develop new or improved materials and processes. Laboratories submit Field Work Proposals annually to the Office of Industrial Technologies. The process of funding on the basis of Field Work Proposals is non-competitive, in accordance with Departmental regulations.

Accutru International, Inc. was in a position to rapidly develop a long-life, high-accuracy contact temperature sensor through the Glass Vision industry participants with minimal financial assistance. This small business had a wealth of expertise in the field, making this one-time investment highly likely and thus reinforcing Glass Vision projects that could benefit industry across the board in a rapid time frame.

Q324. On pages 440 and 481 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for the Glass Vision, it is stated: "Benefits, as stated by industry include: . . . improved energy savings of 0.045 quadrillion Btus representing $180 million reduction of air/water emissions by 20% . . .".

Q324a. Please provide detailed documentation of these claims.

A324a. These benefits encompass the targets identified by industry at the time the 1997 budget was developed. In the Glass Vision process, OIT asked industry what R&D areas would be a priority for them based on how they would want to look, as an industry, in 2020. In order to be a viable industry in the year 2020, they identified these targets as priorities for their industry. For example, an estimation of bringing all glass facilities 50% closer to ideal energy consumption from where they were in 1995 averages out to a 20% improvement overall. Some companies are operating at 6-8 million Btus of energy to melt one ton of glass, where theoretical lies at 2.2 million Btus. In light of energy losses, an improvement to 3.5 million Btus is a probable ideal energy consumption. These targets have been more clearly defined in the Glass Industry Vision, which will be signed by representatives from the industry and the Secretary of Energy on April 29, 1996.

Q324b. Please document why these benefits would not be achieved in the absence of DOE funding.

A324b. The industry is highly competitive and very diverse. Opportunities to work collaboratively between sectors of the industry and within sectors on common precompetitive research has not existed prior to the Glass Vision program. Due to the capital intensive nature of the industry and the reduction of R&D capabilities in-house, a program that pulls together multiple resources from industry and government will create successes that can not be achieved independently. Most of the current R&D is happening overseas, resulting in losses of the market share to foreign competition.

Q325. Please provide a listing of the recipients of (i) the $20,122,000 in funding in FY 1995, (ii) the $12,993,000 in FY 1996 funding, and (iii) the requested level of $13,140,000 in FY 1997 for the Chemicals Vision.

Q326. For each recipient of Chemicals Vision funding identified in the response to question 325 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A325 and A326. See the following table.

Chemicals Vision–
Recipients of Funding and Cost-Sharing
(In Thousands of $)

	Cost-Sharing		
Major Partner	**FY 95**	**FY96**	**FY97**
Biofine	------	110	475
Cargill Research (Cargill Corporation)	------	60	------
Center for Waste Reduction (AICHE)-CWRT	150	150	150
Chevron	------	100	------
Composite Particles, Inc. (CPT)	377	106	600
Cray Research	------	74	------
General Electric	240	573	206
GTC	400	0	0
Lockheed Idaho Technology Co./INEL	200	300	230
NTEC EDSep Inc.	0	400	2,000
NYSERDA	------	150	------
Omni	------	175	------
Recombinant Biocatalysis, Inc.	------	144	------

	Cost-Sharing		
Major Partner	**FY 95**	**FY96**	**FY97**
VRP	------	1,200	1,200
Total	1,367	3,542	4,861

Q327. For those Chemicals Vision funding recipients identified in the response to question 325 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A327. All the projects listed in the table below were awarded on a non-competitive basis either to a National Laboratory, or through a sole source justification to a university, organization, or company.

Program/Project	Project No.	Non-competitive
Advanced Electrodialysis for Separation & Prevention in Process Industries (Food Waste to Lactic Acid)	0407	National Laboratory
Advanced moisture sensor	0177	National Laboratory
Auto Shredder Residue	0339	National Laboratory
Cellulose Waste Minimization and Utilization (Biocatalyst by Design)	0403	National Laboratory
Center for waste reduction technologies (AICHE-CWRT)	0288	Sole source justification, unique capability
Cheese Whey to Ethanol (Alternative Feedstocks Program)	0290	Sole source justification, unique capability
Chemicals from Brightness Stabilization Or High Yield Bleaching Paper (Phenolics)	0553	National Laboratory
CO_2 Dry Cleaning	0367	National Laboratory
Diacid Production from Starch and Oils (Diacids from Biobased Oil Feedstocks) (Alternative Feedstocks Program)	0335	Sole source justification, unique capability
Dow CRADA (Biocatalyst by Design)	0448	National Laboratory
Electroplating Waste Minimization	0174	National Laboratory
Environmental Process Design Modeling	0560	National Laboratory
Enzyme Catalysts for a Biotechnology-based chemical industry	0389	National Laboratory
Flexible Chemical Processing of Post Consumer Polymeric Materials into Chemicals (Caoprolactam from Nylon 5) (Carpet Waste to Caprolactam)	0478	University
Genetic Engineering of Methanogenic Bacteria for Industrial Chemical Applications (Biocatalyst by Design)	0268	National Laboratory
High Capacity Distillation Tray	0317	National Laboratory
Intelligent Vehicle Material Selection System	0480	National Laboratory
Inorganic Polymer Membrane (Polyphosphazene)	0418	National Laboratory
Leveraging the Development of new routes to biobased Chemicals through Historically Black Colleges and Universities (HBCU) (Alternative Feedstocks Program)	0329	Unsolicited
Life Cycle Analysis	0486	University
Life Cycle computer-aided Design (L-CAD)	0048	National Laboratory
Low Temperature Aqueous phase catalytic gasification (Catalytic Gasification)	0283	National Laboratory
Materials Recovery: Appliances	0406	National Laboratory
Materials Recovery: Auto Electronics	0427	National Laboratory
National Center for Manufacturing Sciences (NCMS)	0050	Sole source, unique capabilities

Program/Project	Project No.	Non-competitive
Nondestructive fruit ripeness sensor	0313	National Laboratory
Pollution Assessment and Prevention Software for Chemical Industry Si	0179	National Laboratory
Polyols from Sorbitol	0333	Sole source
Production of Lactic Acid from Renewable Resources (Biomass to Lactic Acid)	0059	National Laboratory
Prompt Non-tire Rubber Recycling (Polymer Recycling: Manufacturing waste Rubber) (Prompt Non-tire Rubber Recycling)	0343	National Laboratory
Rational Enhancement of Enzyme Performance in Organic Solvents	0390	University
Recycling Thermoplastics from Cable/Wire	0482	National Laboratory
Separations by Reversible Chemical Associations	0400	National Laboratory
Supercritical Parts Cleaning	0362	National Laboratory
Theory of Biocatalysis - Electron Transfer Reactions (Biocatalyst by Design)	0269	University

Q328. On page 482 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for the Chemicals Vision, it is stated: "Benefits of these activities include improved efficiency to save at least a quadrillion Btus of energy used by the industry and the reduction of wastes by 2 billion tons per year by 2010. . . . Jobs saved or retained exceed 14,000 person years in 2010."

Q328a. Please provide detailed documentation of the claim that "Benefits of these activities include improved efficiency to save at least a quadrillion Btus of energy used by the industry and the reduction of wastes by 2 billion tons per year by 2010."

A328a. The entire portfolio of Chemical Vision Research and Development Technologies was reviewed and evaluated. The energy savings were reviewed the Office of Policy Analysis (OPA) resulting in the determination that 1 quadrillion BTU's would be saved. The waste reduction value quoted in the budget was in error and should be about 76,000 tons, using the analysis from OPA.

Q328b. Please provide detailed documentation of the claim that "Jobs saved or retained exceed 14,000 person years in 2010."

A328b. The employment impact estimate resulted from an analysis by Charles Teclaw of the U.S. Department of Energy, Office of Policy. It is based upon the Chemical Vision investment in R&D over the next decade of about $100 million to develop new technologies.

Q328c. Please document why these benefits would not be achieved in the absence of DOE funding.

A328c. The industries involved would not have invested in the technology because:

- Industry acting alone usually will not pursue energy conservation process R&D which carries high technical risk or require large capital expenditures in relation to the certainty of success.

- Industry acting alone usually will not pursue R&D which is non-exclusive. The private sector has no incentive to be the leader in R&D unless the benefits of the innovation can be protected.

- Industry alone usually will not perform R&D which responds more to the national welfare than to its own. A variety of relatively slow payback R&D activities fall into this category, and include alternative fuel utilization technology, industrial waste utilization, and materials recycling technology.

- Industry cannot easily perform R&D in direct cooperation among competitors. A promising but very capital intensive, high-risk R&D concept may be beyond the capability of the originating firm, but collaboration with a second firm may violate anti-trust laws.

- Industry alone usually will selectively avoid R&D with a long-term expected payback period. The corporate investment horizon even for R&D is extremely short. Corporate executives are not likely to heavily invest in R&D for which long-term, uncertain payoffs would accrue to their successors.

- Industry cannot perform R&D beyond the firm's or industry association's research capability. The historically low R&D levels in the energy-intensive process industries have resulted in limited research capabilities within these industries. The process industrial sector has not seen a continuous need for innovative state-of-the-art advances, as has been observed, for example by the DOE Energy Advisory Board. ("FY 1987 Energy Conservation MultiYear Plan," DOE Office of Conservation, Washington, DC, 7/85).

- Large firms in mature businesses are cautious about manufacturing process investments.

Needed are:

- Technologies with potential for multiple benefits.
- Energy savings technology with very high return on investment.
- Marginal technology like heat recovery or bottoming cycles.
- Most energy intensive businesses are mature so most new technology is aimed at existing plants.

Industries of the Future (Crosscutting)

Q329. Page 488 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of Industries of the Future (Crosscutting):

Advanced Turbine Systems:

	2000	2010	2020
Total Primary Energy Displaced (quads)	.11	.31	.57
Energy Cost Savings ($billions)	.32	1.27	3.3
Carbon Reductions (million metric tons)	2.23	5.14	8.33

CFCC and Advanced Industrial Materials:

	2000	2010	2020
Total Primary Energy Displaced (quads)	0.12	0.76	0.71
Energy Cost Savings ($billions)	.39	2.91	3.77
Carbon Reductions (million metric tons)	2.09	13.25	11.72

Q329a. Please provide detailed documentation of each of these claimed benefits.

A329a. DOE makes extensive use of an Energy, Economic and Environmental model to identify projects that are deemed appropriate for federal funding and to quantify the benefits resulting from these projects. The model performs a financial analysis based on a comparison of cost, energy and environmental data for the conventional versus the new technology. Using these financial results and target market data, the model predicts market penetration of the new technology over the next 25 years. Based on the market penetration results, the model then calculates the potential energy savings, cost savings and waste reduction over the next 25 years. Once the benefits have been quantified they are distributed to experts inside and outside of DOE for peer review. The discrepancies from the peer review findings are resolved and the benefits are finalized.

Input for the model comes from a variety of sources inside and outside of DOE. The ATS program benefits are based upon Energy Information Administration (EIA) forecasts and the cost and efficiency goals of the program. EIA's "Annual Energy Outlook 1996" (DOE/EIA-0383(96)) was used to determine demand for base load and reserve electric power. Capital and operating costs for conventional technology were drawn from a variety of sources, such as annual *Power and Gas Turbine World* handbooks.

The benefits listed for the CFCC and Advanced Industrial Materials programs are based on a number of applications. The applications for the CFCC Program include candle filters, hot gas filters, heat exchangers, and steam reformers; applications for the Advanced Industrial Materials program include materials for recovery boilers, nickel iron aluminide steel mill rolls, chemical vapor deposition of fiber coatings, and chemical vapor infiltration gas separation membranes.

Other applications are being considered in the CFCC Program. The applications shown are being investigated by the majority of the industrial partners and these applications have the largest market penetration. Including other applications would increase the benefits.

The quality metrics analyses are for only four of the Advanced Materials projects, so the total savings will be considerably larger. For example, testing of only one new application of nickel aluminide as forging dies indicates the material will last more than twenty times as long as steel dies and will save at least 15% of all the energy used in closed die forging operations. There will be other, as yet unpredictable, benefits from the Program.

A breakdown of the benefits is as follows:

For 2000:

Application	**Energy Displaced (Quads)**	**Market Penetration (%)**	**Energy Cost Savings ($ Billions)**	**Carbon Reductions (Million Metric Tons)**
Candle Filters	.001	3	.003	.017
Hot Gas Filters	.007	5	.023	.122
Heat Exchangers	.021	3	.068	.366
Steam Reformers	.021	3	.068	.366
Materials for Recovery Boilers	0	0	0	0
Steel Mill Rolls	.014	30	.046	.244
CVD of Fiber Coatings	0.55	46	.179	.958
Gas Separation Membranes	0	0	0	0

For 2010:

Application	**Energy Displaced (Quads)**	**Market Penetration (%)**	**Energy Cost Savings ($ Billions)**	**Carbon Reductions (Million Metric Tons)**
Candle Filters	.003	26	.012	.052
Hot Gas Filters	.132	97	.504	2.30
Heat Exchangers	.324	49	1.24	5.65
Steam Reformers	.179	33	.684	3.12
Materials for Recovery Boilers	.001	12	.004	.017
Steel Mill Rolls	.013	30	.050	.227
CVD of Fiber Coatings	0.96	100	.367	1.67
Gas Separation Membranes	.017	22	.065	.296

For 2020:

Application	Energy Displaced (Quads)	Market Penetration (%)	Energy Cost Savings ($ Billions)	Carbon Reductions (Million Metric Tons)
Candle Filters	.014	79	.074	.231
Hot Gas Filters	.171	100	.907	2.82
Heat Exchangers	.266	28	1.41	4.38
Steam Reformers	.127	20	.673	2.09
Materials for Recovery Boilers	.003	35	.016	.050
Steel Mill Rolls	.002	3	.011	.033
CVD of Fiber Coatings	.050	44	.265	.824
Gas Separation Membranes	.078	89	.414	1.29

Q329b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A329b. Gas turbine technology would continue to be developed without DOE funding for the Advanced Turbine Systems (ATS) Program but these benefits would not be realized. Without DOE funding for the ATS program, gas turbine technology development would be modest and incremental and have a much different direction. The Advanced Turbine System program grew out of a series of workshops at Clemson University in 1991 -92. These workshops documented, that left to their own devices, the gas turbine manufacturers would not take on the risk of developing clean and energy efficient technology on their own. They stated their limited internal R&D resources would be spent in two areas; first-cost and durability. Without DOE funding they will not focus on improving energy efficiency or reducing environmental emissions (other than that required by regulation). Since the 1980's global competition has been fierce in the gas turbine business. Many have either lost money or are operating at margins as low as 5%. With these small margins there are very little resources available to spend on any long-term technology development. Also most manufacturers are turning to the global market where the customer's major concern is first-cost not the environment. The gas industry, electric utilities, State agencies and the entire California congressional delegation agree and support this program. Without DOE funding the U.S. will not receive the tremendous benefits gas turbine technology brings to the nation in developing a sustainable economy and environment. The California Energy Commission with support from Governor Wilson has taken a very keen interest in the Advanced Turbine System program. They are hosting workshops to ensure there will be no market barriers to the introduction of this technology in California.

The majority of the benefits listed for the CFCC program would not occur without DOE funding. Many of the companies participating in the program would not continue their development of CFCCs without funding from DOE because these materials are still in the development stage with too much risk for a single company to take on its own. Although a few companies might continue some work, very few applications would be investigated and consequently the benefits of these materials would be drastically reduced.

The majority of the projects in the Advanced Materials Program are funded because industry does not have the expertise or unique facilities for their identified needs. One of the selection criteria is that only work that industry cannot do will be funded. As one example, the development of materials for recovery boilers, which is supported in-kind by all the major U.S. pulp and paper companies' two boiler manufacturers, and a tube fabricator, without any DOE money, requires the High Flux Isotope Reactor facility at Oak Ridge for stress analyses and the High Temperature Materials Laboratory and Metals Processing Laboratory at Oak Ridge for strength and microstructural analyses.

Q330. Please provide a listing of the recipients of (i) the $18,524,000 in funding in FY 1995, (ii) the $21,598,000 in FY 1996 funding, and (iii) the requested level of $24,650,000 in FY 1997 for Cogeneration.

A330. Solar Turbines, Allison Engines, Oak Ridge National Lab, Westinghouse, Unitec Technologies.

Q331. For each recipient of Cogeneration funding identified in the response to questior 330 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A331. See the following table.

Cogeneration–Cost-Sharing
(In Millions of $)

	Cost-Sharing		
Funding Recipient(s)	**FY 95**	**FY96**	**FY97**
Solar Turbines	9.49	14.40	15.00
Allison Engines	2.10	4.20	8.00
National Laboratories	0.55	0.40	0.50
Materials Support Contractors	0.70	0.60	0.60
EE Totals	**12.84**	**19.60**	**24.10**

Q332. For those Cogeneration funding recipients identified in the response to question 33 above, please identify those that were awarded funds on a non-competitive basis and provide a justification for each such non-competitive award.

A332. Funds going to the National Laboratories are the only funds that were awarded on a non-competitive basis. This was done since the National Laboratories chosen are the centers o excellence for work in high temperature materials research and are world renown in thi field. There is no other facility that is as well-equipped or has as much expertise as th National Labs in this area. Laboratory funding is based on determination by DOE Projec Mangers that laboratory staff are uniquely qualified to accomplish work assignments.

Q333. Please provide a listing of the recipients of (i) the $18,437,000 in funding in FY 1995, (ii) the $17,577,000 in FY 1996 funding, and (iii) the requested level of $14,700,000 in FY 1997 for Advanced Materials and CFCCs.

Q334. For each recipient of Advanced Materials and CFCCs funding identified in the response to question 333 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A333 and A334. See the following tables. All cost-sharing for the Advanced Industrial Materials Program is from industrial partners of the National Laboratory investigators. Cost-share for the CFCC program is indicated in the following Table. All cost-sharing for the CFCC program is from industrial participants and is in cash contributions to the research except where noted.

Advanced Industrial Materials Program–
Recipients of Funding and Cost-Sharing

Project Title	Funding Recipient(s)	Types of Cost-Sharing	Cost-Sharing (Percent) FY 95	FY96	FY97
Advanced Intermetallic Alloy Development	Oak Ridge NL	CRADAs, In-kind	30	40	TBD
Advanced Microwave Processing	Oak Ridge NL	In-kind	40	40	TBD
Bonded Oxides and Carbides	Oak Ridge NL	In-kind	20	30	N/A
Chemical Vapor Deposition	Sandia NL	In-kind, CRADA, funds in	40	40	TBD
Composite Tubes for Recovery Boilers	Oak Ridge NL	In-kind	50	50	TBD
Polymer Blends from Biobased Materials	Nat. Renew. Energy Lab	None	0	0	N/A
Composites and Coatings	Sandia NL	In-kind, CRADA	25	30	TBD
Conducting Polymers	Los Alamos NL	In-kind	20	20	TBD
CVI of Titanium Diboride	Oak Ridge NL	In-kind	50	50	TBD
Gel Casting Technology	Oak Ridge NL	CRADA	50	50	TBD
Magnetic Field Processing of Organic Polymers	Los Alamos NL	CRADA	50	50	N/A
Microwave Processing of Ceramics	Los Alamos NL	CRADAs	50	50	50
Refractories for Glass	Oak Ridge NL	In-kind	N/A	50	TBD
Inorganic Thin Films	Sandia NL	In-kind, CRADA	20	30	TBD
Synthesis of Intermetallic Alloys*	Los Alamos NL	CRADA, In-kind	40	50	TBD
Transfer Rolls for Steel**	Oak Ridge NL	In-kind	50	50	TBD

Funding transferred to Glass Industry budget for FY 97.
* Funding transferred to Steel Industry budget for FY 97.

CFCC Program–
Recipients of Funding and Cost-Sharing
(In Thousands of $)

		Cost-Sharing		
Project Title	**Funding Recipient(s)**	**FY 95**	**FY96**	**FY97**
Applications for Diesel Valve Guides	AlliedSignal	70	122	TBD
Chemical Vapor Infiltration (CVI)	Amercom	282	307	TBD
Sol Gel Impregnation	Babcock & Wilcox	220*	201	TBD
Polymer Impregnation and Pyrolysis	Dow Corning	290	188	TBD
DIMOX	DuPont Lanxide	168	197	TBD
Heat Management Equipment (CVI)	DuPont Lanxide	274	336	TBD
Toughened Silcomp	General Electric	137	160	
Technology Development/ Performance	Oak Ridge NL	0	0	TBD
Gaseous Nitridation	Textron Specialty Materials	308	269	TBD
Total		**1,749**	**1,780**	**TBD**

*Includes in-kind cost-share.

Q335. For those Advanced Materials and CFCCs funding recipients identified in the response to question 333 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A335. The Advanced Materials Program provides funding only to DOE National Laboratories for the purpose of working with industrial partners to develop new or improved materials and processes. Laboratories submit Field Work Proposals annually to the Office of Industrials Technologies. The process of funding on the basis of Field Work Proposals is non-competitive, in accordance with Departmental regulations.

All of the companies listed in question 333 as participants in the CFCC Program, were awarded their contracts based on a competitive solicitation. The only exception to this is the Oak Ridge National Laboratory which was selected because of their unique expertise and facilities in materials testing and evaluation.

Q336. Please provide a listing of the recipients of (i) the $5,700,000 in funding in FY 1995 and (ii) the $68,000 in FY 1996 funding for Combustion Technologies.

A336. The table below notes the recipients of Combustion Technologies funding in FY 1995 and the cost-sharing that they or other industrial sources provided (in thousands of $). For FY 1996, funding was provided to Idaho National Engineering Laboratory.

Project	Recipient	Cost-Share	Note for Non-Competitive
Pulse Combustion	Georgia Tech	0	(1)
Assym. Whirl Comb.	Princeton University	0	(2)
Combustion Optimization	Institute of Gas Technology	77	
	Brigham Young University	386	
	Energy Research Co.	331	
Waste Driven Heat Pumps	Oak Ridge National Lab.	500	(3)
Market and Tech. Assess	Hagler-Baily	25	
Heated Turbine System	Solar Turbines	237	
Gas Research Center	Penn State	0	(4)
Hydrogen Sulfide Micro.	Argonne National Lab.	0	(5)
Plating Waste Recovery	Los Alamos NL, Boeing	630	(6)
Auto Shredder Residue	Oak Ridge National Lab.	2,400	(7)
	Total	4,586	

Q337. For each recipient of Combustion Technologies funding identified in the response to question 336 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 and FY 1996.

A337. The answer to this question for FY 1995 is shown in the table above. It is significant to note that on average for Combustion Technologies, every DOE dollar was matched by more than 80 cents in industry cost-sharing in FY 1995. No cost sharing was provided to match the very small level of DOE funding in FY 1996.

Q338. For those Combustion Technologies funding recipients identified in the response to question 336 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A338. The numbers in parentheses below correspond to the numbers in parenthesis in the previous table:

(1) Prof. Zinn at Georgia Tech is a world renowned expert in pulse combustion.

(2) Prof. Glassman, a member of the National Academy of Engineering, is an internationally recognized combustion expert. This project is based on a novel combustion concept which he invented.

(3) Oak Ridge National Laboratory has world class capabilities applicable to this heat pump project.

(4) Penn State has a materials center, initially established by GRI, which is capable of evaluation materials samples larger than can be evaluated elsewhere.

(5) Argonne National Laboratory has had many years of experience in this area and has developed unique qualifications applicable to this project.

(6) Los Alamos National Laboratory has world class capabilities applicable to this area. From its work for defense, LANL has had unique experience in electroplating and separations, has highly experienced personnel and specialized laboratory facilities.

(7) Argonne National Laboratory has many years of experience in auto shredder residue management.

Municipal Solid Waste

Q339. Please provide a listing of the recipients of (i) the $2,696,000 in funding in FY 1995 and (ii) the $195,000 in FY 1996 funding for Municipal Solid Waste.

A339. In FY 1995, funding from the Energy Conservation appropriation for Municipal Solid Waste was provided to National Renewable Energy Laboratory; Research Triangle Institute; Argonne National Laboratory; American Society of Mechanical Engineers; Pellet Fuels Institute; Camp, Dresser & McKee. In FY 1996, funding was provided to National Renewable Energy Laboratory.

Q340. For each recipient of Municipal Solid Waste funding identified in the response to question 339 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 and FY 1996.

A340. The level of project cost-share is provided in the following table which reflects the Interior appropriation for municipal solid waste:

Municipal Solid Waste–Cost-Sharing
(In Thousands of $)

	Cost-Sharing from Others	
Recipient	**FY 95**	**FY96**
National Renewable Energy Laboratory	0	0
Research Triangle Institute	265	0
Argonne National Laboratory	166	0
American Society of Mechanical Engineers	190.5	0
Pellet Fuels Institute	125	0
Camp, Dresser & McKee	30	0
Total	776.5	0

Q341. For those Municipal Solid Waste funding recipients identified in the response to question 339 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A341.

Recipient	Justification
National Renewable Energy Laboratory	Unique technical and management expertise in municipal solid waste technologies including combustion ash beneficial use.
Argonne National Laboratory	Unique technical expertise in refuse-derived-fuel combustion and landfill research.

Recipient	Justification
Pellet Fuels Institute	Technology and resources available within this trade association needed to support commercialization efforts.
American Society of Mechanical Engineers	Exclusive ability to provide, gratis, an oversight task force of experts.

Technology Access

Q342. Page 503 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the Industrial Assessment Centers (IACs)/Technology Transfer Program:

	2000	2010	2020
Energy Savings (quads)	**.012**	**.014**	**.011**
Energy Cost Savings ($billions)	**.01**	**.01**	**.01**
Carbon Savings (MMTCE)	**.04**	**.04**	**.04**

Q342a. Please provide detailed documentation of each of these claimed benefits.

A342a. The benefits of the program are calculated by summing the engineering estimates of energy and waste savings resulting from the implementation of those recommendations. These implementation rates are based on actual surveys of assessment recipients. It is assumed that energy and waste savings effects persist for five years. Benefits are projected by using the past average Btu savings and carbon reductions multiplied by the number of assessments times the estimated implementation rate times five years. The program benefits are calculated on the attached spreadsheet. Since the release of the current revision of the budget new numbers have been made available. The new updated annual numbers are as follows:

	FY 2000	FY 2010	FY 2020
Energy Savings (quads)	.003	.003	.003
Energy Cost Savings ($billions)	.058	.058	.058
Carbon Savings (MMTCE)	.074	.074	.074

Cumulative IAC Savings

Year	Audits Perf.	Assess. Perf.	Rec.. Energy Savings($)	Rec.. Non-Energy Savings($)	Total Rec.. Savings ($)	Impl. Energy Savings($)	Impl. Non-Energy Savings($)	Total Impl. Savings($)	Rec.. Energy Savings (MMBTU)
76-77	see 1	N/A	746,642	N/A	746,642	373,321	N/A	373,321	298,694
77-78	see 1	N/A	510,801	N/A	510,801	255,401	N/A	255,401	252,619
78-79	see 1	N/A	6,093,682	N/A	6,093,682	3,046,841	N/A	3,046,841	2,304,744
79-80	see 1	N/A	2,353,683	N/A	2,353,683	1,176,842	N/A	1,176,842	812,581
80-81	15	N/A	3,339,289	N/A	3,339,289	2,617,567	N/A	2,617,567	798,104
81-82	253	N/A	6,699,741	N/A	6,699,741	1,839,122	N/A	1,839,122	1,106,943
82-83	211	N/A	8,712,422	N/A	8,712,422	1,923,834	N/A	1,923,834	1,520,973
83-84	248	N/A	8,979,598	N/A	8,979,598	4,591,834	N/A	4,591,834	1,278,278
84-85	368	N/A	13,917,967	N/A	13,917,967	7,007,105	N/A	7,007,105	2,186,558
85-86	298	N/A	13,640,445	N/A	13,640,445	6,677,381	N/A	6,677,381	1,663,618
86-87	324	N/A	10,751,519	N/A	10,751,519	5,866,384	N/A	5,866,384	1,101,577
87-88	388	N/A	13,603,630	N/A	13,603,630	6,149,840	N/A	6,149,840	1,503,026
88-89	340	N/A	13,081,589	N/A	13,081,589	7,509,294	N/A	7,509,294	1,780,449
89-90	360	N/A	14,028,351	N/A	14,028,351	6,628,891	N/A	6,628,891	1,568,225
90-91	455	N/A	17,373,265	N/A	17,373,265	8,464,119	N/A	8,464,119	1,290,537
91-92	531	N/A	21,804,001	N/A	21,804,001	10,185,850	N/A	10,185,850	2,035,676
92-93	585	N/A	27,042,250	2,596,381	29,638,631	9,363,870	1,607,717	10,971,587	2,429,267
93-94	716	60	35,542,867	6,870,839	42,413,706	12,169,824	3,121,562	15,291,386	3,497,670
94-95*	659	220	40,446,628	13,084,747	53,531,374	13,927,482	6,025,169	19,952,651	4,053,927

* Savings are calculated using averages calculated for the previous 2 years and then ratios are used to determina energy and non-energy savings.

1. The number of audits for these years was not recorded

All numbers are annual

Avg. rec.. energy savings per audit	46,014
Avg. rec.. non-energy savings per audit	59,476
Avg. Impl. energy savings per audit	15,845
Avg. Impl. non-energy savings per audit	27,387

All other estimates are based on previous 14 years of data

MMBTU Calculation			Carbon Equivqlent (CE) reduction calculation	
Number of audits from 81-94	5,152			
Rec.. Energy MMBTUs savings	23,760,901		Rec.. Carbon reduction	549,569
Impl. Energy MMBTU savings	12,175,317		Impl. Carbon Reduction	281,606
Rec.. MMBTUs per audit	4,812		Rec.. Carbon reduction per audit	107
Impl. MMBTUs per audit	2,363		Impl. Carbon reduction per audit	55

Barrels of Oil Equivalent calculation	
Rec.. BOE	4,079,107
Impl. BOE	2,090,185
Rec.. BOE per audit	792
Impl. BOE per audit	406

Sum of energy rec.. savings for last five years	142,209,011
Sum of energy impl. savings for last five years	54,111,145
Energy Impl. Rate (5 yrs)	38.05%
Sum of non-energy rec.. savings for last three years	22,551,967
Sum of non-energy impl. savings for last three years	10,754,448
Non-energy Impl. Rate (3 yrs)	47.69%
Cum.. Impl. Savings through FY95	444,832,464
Energy Impl. rate for FY 95	34.43%
Energy Impl. rate for FY 96	34.43%

Determine projected yearly savings by using energy and non-energy audit averages

The projected yearly implemented savings are as follows

	Dollars	BTUs	CE	BOE	
96	$37,611,686	2,056,003	47,554	352,962	(Only 870 assessments will be performed)
97	$38,908,641	2,126,899	49,194	365,133	
98	$38,908,641	2,126,899	49,194	365,133	
99	$38,908,641	2,126,899	49,194	365,133	
2000	$38,908,641	2,126,899	49,194	365,133	

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Q342b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A342b. These savings would not be achieved if there was no funding for the IAC program. The IAC program was developed because a great number of small and medium sized manufacturers do not have the expertise or resources to perform assessments for themselves. Thus, these significant dollar savings and energy reductions are achieved because of DOE support. A concurrent benefit is the training in this expertise provided to young engineering professionals working in this program.

Q343. Page 504 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following IACs/Technology Transfer performance metrics for FY 1995 and FY 1996:

Measure:	**1995**	**1996**
Univ. Partners	**30**	**30**
# of Audits	**900**	**900**
Annual Energy Savings (billion Btus)	**4**	**4**
% Acted Upon	**40**	**40**
Annual Waste Savings Identified and Acted Upon Per Audit	**$16,245**	**$16,245**

Please provide detailed documentation for each of these claimed performance metrics in FY 1995 and FY 1996, including identification of each "Univ. Partners" and DOE funding provided to each such partnership in FY 1995 and FY 1996.

A343. The IAC program has 30 university partners located throughout the country. DOE provides funding to these universities and the universities maintain an assessment center. These centers provide no-cost audits to small- and medium-sized manufacturers located within 150 miles of the center. To receive full funding each center is required to complete 30 assessments. An annual total of 900 assessments are determined by multiplying the number of centers by the number of required assessments.

Annual energy savings are actual numbers based on confirmation interviews with manufacturers receiving IAC services. A national database with assessments and survey results is maintained at Rutgers, The State University of New Jersey. This database contains the results of over 6,000 site visits and is accessible to the public through the Internet. There are approximately 120 downloads of the database monthly.

The following table contains updated numbers based on the spreadsheet above.

	FY 1995	FY 1996
University Partners	30	30
Number of Audits	900	900
Annual Energy Savings (Billion Btus)	4.6	4.6
Percent Acted Upon	37%	34%
Annual Waste Savings Identified and Acted Upon Per Audit	$27,387	$27,387

The following is a listing of university partners and their funding:

University Partners	FY 1995	FY 1996 (Est.)
University of Dayton-Dayton, OH	$155,700	$161,810
University of Florida-Gainesville, FL	$155,700	$161,810
Georgia Institute of Technology-Atlanta, GA	$185,700	$161,810
Hofstra University-Hempstead, NY	$155,700	$161,810
University of Louisville-Louisville, KY	$185,700	$161,810
University of Maine- Orono, ME	$185,700	$161,810
University of Massachusetts-Amherst, MA	$156,735	$161,810
University of Michigan-Ann Arbor, MI	$120,450	$161,810
Mississippi State University-Mississippi, MS	$120,450	$161,810
North Carolina State University- Raleigh, NC	$185,700	$161,810
University of Notre Dame-Notre Dame, IN	$155,700	$161,810
Old Dominion University-Norfolk, VA	$120,450	$161,810
University of Tennessee-Knoxville, TN	$167,280	$161,810
West Virginia University-Morgantown, WV	$155,700	$161,810
University of Wisconsin-Milwaukee, WI	$155,700	$161,810
Arizona State University-Tempe, AZ	$150,050	$161,810
University of Arkansas at Little Rock-Little Rock, AR	$155,700	$161,810
Bradley University-Peoria, IL	$120,450	$161,810
Colorado State University-Fort Collins, CO	$155,700	$161,810
Iowa State University-Ames, IA	$155,700	$161,810
University of Kansas-Lawrence, KS	$50,345	$161,810
University of Missouri at Rolla-Rolla, MO	$185,700	$161,810
University of Nevada at Reno-Reno, NV	$120,450	$161,810
Oklahoma State University- Stillwater, OK	$155,700	$161,810
Oregon State University- Corvallis, OR	$155,700	$161,810
San Diego State University-San Diego, CA	$155,700	$161,810
San Francisco State University-San Francisco, CA	$155,700	$161,810
South Dakota State University- Brookings, SD	$120,450	$161,810
Texas A&M University-College Station, TX	$155,450	$161,810
Texas A&M University at Kingsville-Kingsville, TX	$120,450	$161,810
Total	**$4,475,610**	**$4,854,300**

The FY95 funding variances reflect awards for collaborative workshops between States and IACs along with reduced funding to those centers yet to be trained in combined energy, waste, and productivity assessment work.

Q344. Please provide a listing of the recipients of (i) the $9,015,000 in funding in FY 1995, (ii) the $8,472,000 in FY 1996 funding, and (iii) the requested level of $9,886,000 in FY 1997 for IACs/Technology Transfer.

A344. Funding recipients for FY 1995, FY 1996 and FY 1997 are shown below (x denotes received funding, ------ denotes did not receive funding).

Recipient	FY 95	FY96	FY97
IAC			
Rutgers, the State University of New Jersey	x	x	x
University of Dayton-Dayton, OH	x	x	x
University of Florida-Gainesville, FL	x	x	x
Georgia Institute of Technology-Atlanta, GA	x	x	x
Hofstra University-Hempstead, NY	x	x	x
University of Louisville-Louisville, KY	x	x	x
University of Maine- Orono, ME	x	x	x
University of Massachusetts-Amherst, MA	x	x	x
University of Michigan-Ann Arbor, MI	x	x	x
Mississippi State University-Mississippi, MS	x	x	x
North Carolina State University-Raleigh, NC	x	x	x
University of Notre Dame-Notre Dame, IN	x	x	x
Old Dominion University-Norfolk, VA	x	x	x
University of Tennessee-Knoxville, TN	x	x	x
West Virginia University-Morgantown, WV	x	x	x
University of Wisconsin-Milwaukee, WI	x	x	x
University City Science Center	x	x	x
Arizona State University-Tempe, AZ	x	x	x
University of Arkansas at Little Rock-Little Rock, AR	x	x	x
Bradley University-Peoria, IL	x	x	x
Colorado State University-Fort Collins, CO	x	x	x
Iowa State University-Ames, IA	x	x	x
University of Kansas-Lawrence, KS	x	x	x
University of Missouri at Rolla-Rolla, MO	x	x	x
University of Nevada at Reno-Reno, NV	x	x	x
Oklahoma State University- Stillwater, OK	x	x	x
Oregon State University-Corvallis, OR	x	x	x
San Diego State University-San Diego, CA	x	x	x
San Francisco State University-San Francisco, CA	x	x	x
South Dakota State University- Brookings, SD	x	x	x
Texas A&M University-College Station, TX	x	x	x
Texas A&M University at Kingsville-Kingsville, TX	x	x	x
Tennessee Dept. of Econ. and Community Development-Nashville, TN	x	------	------
California State Energy Office	x	------	------
Texas State Energy Office	x	------	------
Washington State Energy Office	x	------	------
Oak Ridge Institute for Science and Education-Oak Ridge, TN	x	x	------
RMCI-Washington, DC	x	------	------
Technology Transfer/ EPAct			
National Renewable Energy Laboratory (NREL)	x	x	x
Pacific Northwest Laboratory (PNL)	x	x	x
Denver Support Office	x	------	------
American Council for an Energy Efficient Economy (ACEEE)	x	------	------
Oak Ridge National Laboratory	x	------	------

Recipient	FY 95	FY96	FY97
Office of Science and Technical Information (OSTI)	------	x	x
Vista Technologies	------	x	------

Q345. For each recipient of IACs/Technology Transfer funds identified in the response to question 344 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A345. Participants who provided cost-sharing are:

Recipient	Cost-Share		
	FY95	FY96	FY97
University of Dayton-Dayton, OH	$23,355	$24,272	$24,272
University of Florida-Gainesville, FL	$23,355	$24,272	$24,272
Georgia Institute of Technology-Atlanta, GA	$23,355	$24,272	$24,272
Hofstra University-Hempstead, NY	$23,355	$24,272	$24,272
University of Louisville-Louisville, KY	$23,355	$24,272	$24,272
University of Maine- Orono, ME	$23,355	$24,272	$24,272
University of Massachusetts-Amherst, MA	$23,355	$24,272	$24,272
University of Michigan-Ann Arbor, MI	$18,068	$24,272	$24,272
Mississippi State University-Mississippi, MS	$18,068	$24,272	$24,272
North Carolina State University-Raleigh, NC	$23,355	$24,272	$24,272
University of Notre Dame-Notre Dame, IN	$23,355	$24,272	$24,272
Old Dominion University-Norfolk, VA	$18,068	$24,272	$24,272
University of Tennessee-Knoxville, TN	$23,355	$24,272	$24,272
West Virginia University-Morgantown, WV	$23,355	$24,272	$24,272
University of Wisconsin-Milwaukee, WI	$23,355	$24,272	$24,272
Arizona State University-Tempe, AZ	$22,508	$24,272	$24,272
University of Arkansas at Little Rock-Little Rock, AR	$23,355	$24,272	$24,272
Bradley University-Peoria, IL	$18,068	$24,272	$24,272
Colorado State University-Fort Collins, CO	$23,355	$24,272	$24,272
Iowa State University-Ames, IA	$23,355	$24,272	$24,272
University of Kansas-Lawrence, KS	$7,552	$24,272	$24,272
University of Missouri at Rolla-Rolla, MO	$23,355	$24,272	$24,272
University of Nevada at Reno-Reno, NV	$18,068	$24,272	$24,272
Oklahoma State University- Stillwater, OK	$23,355	$24,272	$24,272
Oregon State University-Corvallis, OR	$23,355	$24,272	$24,272
San Diego State University-San Diego, CA	$23,355	$24,272	$24,272
San Francisco State University-San Francisco, CA	$23,355	$24,272	$24,272
South Dakota State University- Brookings, SD	$18,068	$24,272	$24,272
Texas A&M University-College Station, TX	$23,355	$24,272	$24,272
Texas A&M University at Kingsville-Kingsville, TX	$18,068	$24,272	$24,272
Rutgers University	$66,500	$66,500	$66,500
Total, IAC	**$647,656**	**$794,660**	**$794,660**

Technology Transfer/EPAct: Provides office-wide support and funding is not applicable.

Q346. For those IACs/Technology Transfer funding recipients identified in the response to question 345 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A346. None of the recipients of funding in question 345 were awarded funding on a non-competitive basis. All IACs were selected competitively. No cost-sharing is involved in the Technology Transfer and EPAct activities.

Q347. On page 507 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated in the FY 1996 column for IACs/Technology Transfer: "Yearly implemented savings exceed $22.4 million and 1.7 trillion Btu. Cumulative savings amount to $970 million and 155 trillion Btu."

Q347a. Please provide detailed documentation of these claims, including the peer review process undertaken.

A347a. New numbers have been made available since the current revision of the budget. As shown on the attached spreadsheet. the new numbers should be "Yearly implemented savings exceed $37.6 million and 2.0 trillion BTU. Cumulative savings amount to $539 million and 73 trillion BTU. Peer review is not applicable to the IAC activities. However, technical review of all IAC client reports is provided by the appropriate regional IAC field management staff.

Q347b. Please document why these benefits would not occur in the absence of DOE funding.

A347b. These savings would not be achieved without funding for the IAC program. The small- and medium-sized manufacturing community who receive this service do not have the expertise or resources to perform assessments for themselves. Thus, these significant dollar savings and energy reductions would not be achieved without the DOE support. An additional benefit of the IAC program is the hands-on training in energy and waste management provided to young engineering professionals. Approximately 1700 students have received this training with some 340 students in training at this time.

Cumulative IAC Savings

Year	Audits Perf.	Assess. Perf.	Rec.. Energy Savings($)	Rec.. Non-Energy Savings($)	Total Rec.. Savings ($)	Impl. Energy Savings($)	Impl. Non-Energy Savings($)	Total Impl. Savings($)	Rec.. Energy Savings (MMBTU)
76-77	see 1	N/A	746,642	N/A	746,642	373,321	N/A	373,321	298,694
77-78	see 1	N/A	510,801	N/A	510,801	255,401	N/A	255,401	252,619
78-79	see 1	N/A	6,093,682	N/A	6,093,682	3,046,841	N/A	3,046,841	2,304,744
79-80	see 1	N/A	2,353,683	N/A	2,353,683	1,176,842	N/A	1,176,842	812,581
80-81	15	N/A	3,339,289	N/A	3,339,289	2,617,567	N/A	2,617,567	798,104
81-82	253	N/A	6,699,741	N/A	6,699,741	1,839,122	N/A	1,839,122	1,106,943
82-83	211	N/A	8,712,422	N/A	8,712,422	1,923,834	N/A	1,923,834	1,520,973
83-84	248	N/A	8,979,598	N/A	8,979,598	4,591,834	N/A	4,591,834	1,278,278
84-85	368	N/A	13,917,967	N/A	13,917,967	7,007,105	N/A	7,007,105	2,186,558
85-86	298	N/A	13,640,445	N/A	13,640,445	6,677,381	N/A	6,677,381	1,663,618
86-87	324	N/A	10,751,519	N/A	10,751,519	5,866,384	N/A	5,866,384	1,101,577
87-88	388	N/A	13,603,630	N/A	13,603,630	6,149,840	N/A	6,149,840	1,503,026
88-89	340	N/A	13,081,589	N/A	13,081,589	7,509,294	N/A	7,509,294	1,780,449
89-90	360	N/A	14,028,351	N/A	14,028,351	6,628,891	N/A	6,628,891	1,568,225
90-91	455	N/A	17,373,265	N/A	17,373,265	8,464,119	N/A	8,464,119	1,290,537
91-92	531	N/A	21,804,001	N/A	21,804,001	10,185,850	N/A	10,185,850	2,035,676
92-93	585	N/A	27,042,250	2,596,381	29,638,631	9,363,870	1,607,717	10,971,587	2,429,267
93-94	716	60	35,542,867	6,870,839	42,413,706	12,169,824	3,121,562	15,291,386	3,497,670
94-95*	659	220	40,446,628	13,084,747	53,531,374	13,927,482	6,025,169	19,952,651	4,053,927

* Savings are calculated using averages calculated for the previous 2 years and then ratios are used to determine energy and non-energy savings.

1. The number of audits for these years was not recorded

All numbers are annual

Avg. rec.. energy savings per audit	46,014
Avg. rec.. non-energy savings per audit	59,476
Avg. Impl. energy savings per audit	15,845
Avg. Impl. non-energy savings per audit	27,387

All other estimates are based on previous 14 years of data

MMBTU Calculation	
Number of audits from 81-94	5,152
Rec.. Energy MMBTUs savings	23,760,901
Impl. Energy MMBTU savings	12,175,317
Rec.. MMBTUs per audit	4,612
Impl. MMBTUs per audit	2,363

Carbon Equivqlent (CE) reduction calculation	
Rec.. Carbon reduction	549,569
Impl. Carbon Reduction	281,606
Rec.. Carbon reduction per audit	107
Impl. Carbon reduction per audit	55

Barrels of Oil Equivalent calculation	
Rec.. BOE	4,079,107
Impl. BOE	2,090,185
Rec.. BOE per audit	792
Impl. BOE per audit	406

Sum of energy rec.. savings for last five years	142,209,011
Sum of energy impl. savings for last five years	54,111,145
Energy Impl. Rate (5 yrs)	38.05%
Sum of non-energy rec.. savings for last three years	22,551,967
Sum of non-energy impl. savings for last three years	10,754,448
Non-energy Impl. Rate (3 yrs)	47.69%
Cum.. Impl. Savings through FY95	444,832,464
Energy Impl. rate for FY 95	34.43%
Energy Impl. rate for FY 96	34.43%

Determine projected yearly savings by using energy and non-energy audit averages

The projected yearly implemented savings are as follows

	Dollars	BTUs	CE	BOE	
96	$37,611,686	2,056,003	47,554	352,962	(Only 870 assessments will be performed)
97	$38,908,641	2,126,899	49,194	365,133	
98	$38,908,641	2,126,899	49,194	365,133	
99	$38,908,641	2,126,899	49,194	365,133	
2000	$38,908,641	2,126,899	49,194	365,133	

Q348. On page 507 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated in the FY 1997 column for IACs/Technology Transfer: "Yearly implemented savings exceed $25 million and 2.16 trillion Btu. Cumulative savings amount to $531 million and 65 trillion Btu."

Q348a. Please provide detailed documentation of these claims, including the peer review process undertaken.

Q348a. New numbers have been made available since the current revision of the budget. As shown on the above spreadsheet. the new numbers should be "Yearly implemented savings exceed $58 million and 3.1 trillion BTU. Cumulative savings amount to $681 million and 83 trillion BTU." Peer review is not applicable to the IAC activities. However, technical review of all IAC client reports is provided by the appropriate regional IAC field management staff.

Q348b. Please document why these benefits would not occur in the absence of DOE funding.

Q348b. These savings would not be achieved without funding for the IAC program. The small- and medium- sized manufacturing community who receive this service do not have the expertise or resources to perform assessments for themselves. Thus, these significant dollar savings and energy reductions would not be achieved without the DOE support.

Q349. Page 503 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the Motor Challenge Program:

	2000	2010	2020
Energy Savings (quads)	.13	.40	.52
Energy Cost Savings ($billions)	.59	3.0	3.9
Carbon Savings (MMTCE)	2.87	8.97	11.50

Q349a. Please provide detailed documentation of each of these claimed benefits.

A349a DOE and the current 1,300(+) Motor Challenge Partners are targeting all types of industrial motor-driven system efficiency opportunities. Industry spends over $30 billion annually on motor system electricity. The Motor Challenge program has been designed by industry for industry to reduce U.S. industry's electric bill by $590 million per year by the year 2000.

Tracking/measuring of Motor Challenge program benefits is estimated for each of the following three program elements as explained below:

a) Showcase Demonstration projects: The 33 Showcase Demonstration projects that are currently in place are investing $15 million collectively and will save an estimated $5 million annually with no direct financial assistance from DOE to the Showcase teams. DOE will provide technical assistance, an independent performance validation, and develop a case study for each project. The goal is to complete 50 Showcase Demonstrations by 2000 providing convincing testimonials, documented cost/benefits, and validated results directly saving 200 million kilowatt-hours per year (2.1 trillion Btu, 46,000 tons carbon savings), and $9.4 million in annual cost savings. [**Detailed analysis:** The energy savings estimates for 50 Showcase Demonstrations were largely based on the most recent estimates of the energy savings from the 33 on-going projects which will save approximately $5 million annually, and a projection as to what the additional 17 projects would be expected to save. DOE will be seeking new projects that offer large energy savings and that are highly replicable throughout industry.]

Once a project is complete (a case study is published), the Motor Challenge program and its partners will encourage broad replication by disseminating the results to companies with similar electric motor system applications. It is estimated that these 50 Showcase projects will be the impetus for 500 more replicated applications (10:1 ratio). This will result in an additional 2.7 billion kilowatt-hour per year in energy savings (27.9 trillion Btu, 0.621 million tons carbon savings) and $127 million in annual cost savings. [**Detailed analysis:** The indirect Showcase Demonstration savings were estimated by assuming that the 500 targeted "Showcase replication" plant sites would have an average motor system electricity consumption of 250 million kW-hr per year (about $12 million cost), and the average motor system energy savings would be 2% of that consumption as achieved through a project similar to any particular Showcase Demonstration.]

b) Excellence Partner Program: A Motor Challenge Excellence Partner is a company making a commitment to developing and implementing a flexible plan that will lead to the continual improvement of motor-driven system management practices within their participating plant sites. Each company will have a number of plant sites participating in the Excellence Partner program (most likely about 10 sites). It was projected that 850 plant sites will be participating in the Excellence Partner program by 2000. [**Detailed analysis:** It was assumed that the 850 plant sites will be concentrated in seven energy intensive process industries (i.e., pulp and paper, chemicals, refining, aluminum, steel, glass, metal castings). That is, of the 850 Excellence Partner plant sites, 60% of the sites (510 total) were assumed to be medium- or large-plant sites (with over 100 employees per site) within these seven industrial sectors. The 510 plant sites comprise 6% of the total plant sites of this size. More importantly, these seven industrial sectors consume 40% of U.S. industry's motor system electricity.]

Excellence Partner plant sites will be implementing a variety of motor system management practices that will assist all types of plant employees to continually improve equipment and process design procedures, purchasing specification, and maintenance practices related to motor-driven systems. Excellence Partners will be working with Motor Challenge to measure and track the company's improvement in managing their motor systems and to document their energy savings. Excellence Partners will save 5.17 billion kilowatt-hour per year in electricity savings by 2000 (53.4 trillion Btu, 1.19 million tons carbon savings) and $244 million in energy savings. [**Detailed analysis:** Using market data, the motor system energy consumption and energy savings potential per plant was defined (savings potential ranged from 8% to 33% of total motor system electricity consumption, and depends highly on the type of industry). A projection was made as to percentage of energy savings potential that would be captured over a three-year period for any Excellence Partner plant site. The results of this analysis showed that the 850 plant sites would have an average motor system electricity consumption of about 100 million kWh per year (about $5 million in energy costs), and would achieve an average plant motor system energy savings of $300,000 per year as part of their Excellence Partnership–about 6% per plant.]

c) Allied Partner Program: The U.S. manufacturing sector is huge and larger than the Motor Challenge program could ever expect to reach by itself. Allied Partners are companies that work with plants daily–trouble-shooting, advising, introducing new equipment. Therefore, the opportunities are abundant for Allied Partners to share information with their customers about options for improving motor system efficiency. By DOE working with Allies, Motor Challenge can reach a larger audience and significantly leverage tax dollars at the same time. Allied Partners are working with DOE to deliver valuable information needed by industrial end-users to make more informed decisions about the purchase, design, maintenance, and management of their electric motor systems.

Allied Partners will be typically industry product suppliers and/or service providers that market motor system technology, and related services to industry, such as motor and drive suppliers or distributors; original equipment manufacturers of pumps, fans, and compressors; electric utilities; etc. Allies could also be trade associations and State agencies. Motor Challenge information, tools, and training curriculum products are highly desired by both industrial suppliers and users because they represent unique sources of information that have been independently validated, and originate from an unbiased source with no vested interest–DOE.

It was projected (based on the current high level of interest in the Allied Partner program, e.g., companies attending meetings and following through in developing action plans) that by 2000, 475 Allied Partners would assist, service, and influence 3,050 end-user companies to save energy. The 3,050 end-user sites that will be assisted and influenced by Allied Partners are projected to save 4.45 billion kilowatt-hour per year in electricity savings (45.9 trillion Btu, 1.02 million tons carbon savings) and $210 million in energy savings. [**Detailed analysis:** The analysis differentiated by the type of Allied Partner (e.g., distributor, OEM, utility, etc.) in that different Allies were assumed to be able to influence a different number of end-users. It was assumed that each end-user influenced would typically be smaller-sized plants (compared to the Excellence Partner plant sites), and would have a motor system energy consumption of 20 million kW-hr/yr (about $1 million in energy costs). It was also assumed that the energy savings achieved by end-users as influenced by the Allies would be 1% of the total motor system energy consumption in the first year the user and Ally work together, and another 1% in the second year. The results of this analysis showed that the 3,050 plant sites influenced by Allied Partners would have an average motor system energy savings of $70,000 per year.]

The corresponding benefits projected in 2010 and 2020 were developed similarly to the year 2000 projections. The development and adoption of new types of best practices, tools, protocols, and motor system management practices within the next 4 years through a variety of Motor Challenge partner efforts and activities will lay the groundwork for an accelerated implementation of a wide range of motor system efficiency opportunities over the next 25 years.

Summary of Motor Challenge Year 2000 Program Metrics

Program Element	**Industry Plant Site**	**Energy Savings, Quads (Trillion Btu) per Year**	**Million Kilowatt-Hours/Year**	**Energy Cost Savings, $ Million per Year**	**Carbon Savings (MMTCE per Year**
Showcase Demonstrations, direct savings	50 sites/projects	0.0021 (2.1)	200	9	0.046
Showcase Demonstrations, indirect replication	500 applications replicated	0.0279 (27.9)	2,700	127	0.621
Excellence Partners	850 plant sites	0.0534 (53.4)	5,170	244	1.189
Allied Partners	475 Allied Partners; 3,050 end-user plants sites influenced	0.0459 (45.9)	4,450	210	1.024
Total	**N/A**	**0.1293 (129.3)**	**12,520**	**590**	**2.88**

Q349b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A349b. Motor Challenge was conceived and developed as a result of significant input from U.S. industry since 1992. Industry worked with DOE to identify the barriers which are impeding industry from adopting efficient motor systems in an accelerated and expanded manner. Similarly, industry suggested (and continues to suggest) a variety of activities that DOE should either facilitate and/or directly support and manage. Accordingly, the purpose of the Motor Challenge program is to address barriers and opportunities through stakeholder initiatives in partnership with industrial end-users, motor and drive manufacturers, original equipment manufacturers (e.g., pumps, fans and compressors), distributors, utilities, and others involved directly, or which can influence the motor-driven systems market. By necessity, activities within the Motor Challenge are commonly focused on market relationships that don't naturally result from prevailing incentives in the marketplace. By acting in a facilitation role, DOE is assisting industry to capture the enormous level of motor system efficiency opportunity by working to remove obstacles and enabling more rapid adoption of more optimum systems and improved management strategies. The opportunities are in systems optimization. Therefore, the DOE Motor Challenge program is in a unique position to bring together and catalyze people, companies, and organizations to focus upon and capture motor system efficiency benefits. These opportunities would not be targeted and invested in without DOE's impetus.

One very important suggestion made by industry was for DOE to collaborate with market participants in the development and dissemination of information, design-decision tools, and best practices. Industry is constantly seeking information and tools to design, specify and purchase industrial equipment and systems. To satisfy these needs, DOE is developing unbiased and validated information and tools in a manner that does not compete with the market.

The following provides specific experiences and examples of how Motor Challenge has made a difference in how industry has more aggressively focused on motor systems opportunities within individual companies and as part of Motor Challenge initiatives:

Showcase Demonstrations: The Showcase Demonstrations have been highly successful in raising the visibility of a variety of efficiency actions within the participating company plants. Many of these projects have helped the Showcase teams to identify new technical system options that were not previously known (or well understood), and are validating and proving these applications to be economic where previously they were perceived to be marginally justified or risky. In other projects the Showcase energy efficiency projects have been known for years, but have not had sufficient visibility and support within the company to gain funding. Designation as a Showcase Demonstration project brings outside validation of the importance of the project, which in turn brings high-level management support. For example, the Lockheed Martin (Armament Systems Division; Burlington, VT) Showcase is a good example of a project that was recognized previously, but was put on the "back burner." However, the company decided to fund the project because of the visibility gained through Motor Challenge Showcase designation. With the project now a completed success, the Lockheed Martin project has gained recognition throughout the corporation, is being highlighted by the corporation in the company's annual report, and is being highlighted in national trade magazines (e.g., *Plant Engineering*) as a case study. Moreover, this project has assisted the Armament Division to be recognized as the leading energy efficiency plant within the Lockheed Martin Corporation.

Allied Partner Program: Allied Partners are constantly striving for ways to serve their industrial end-user customers better and to promote energy efficiency. Therefore, the primary benefit of the partnership between DOE and Allied Partner companies/organizations is that: (1) it helps DOE to cost-effectively reach dramatically more end-users than DOE could reach on its own; and (2) the partnership assists the Allies in validating their message about the benefits of energy efficient motor-driven systems. Motor Challenge provides the tools and information that builds customer awareness and appreciation of the benefits of energy-efficient motor-driven systems. This awareness creates a receptive audience for innovative and efficient technology and services available through the Allies Partners and others. The products that DOE provides are highly needed resources and respond to a repeated end-user demand for reliable, accurate, and unbiased information to help them make informed decisions when designing, specifying, and purchasing efficient motor systems. The Allied Partner program aims to deliver Motor

Challenge products (information, tools, best practices, training curriculum, etc.) that end-users need through the existing market–the Allies.

Accordingly, Motor Challenge is in a unique role to provide independent validation to the Allied Partners promotion of energy efficiency without specifically endorsing any particular company or product. The Motor Challenge efficiency endorsement, however, must be buttressed with substantial information, design-decision tools, best practices and case studies for end-users to more easily and cost-effectively capture the opportunities. In order to reach thousands of end-users, DOE will be relying on the Allied Partners to deliver Motor Challenge products.

The Motor Challenge Motor Master Plus software tool is a good example of a product that Allied Partners are very interested in using to promote motor system efficiency to their customers. While providing independent validation, Motor Master Plus assists end user companies to more comprehensively manage the motors in their plant. Allied Partners will be helping end-users to use the Motor Master Plus tool in managing the motor systems within a customer's plant. Any one individual company could not justify developing the Motor Master Plus software on their own, and even if they could, Allied Partners are seeking the independent validation from DOE through this type of tool.

Excellence Partner program: In developing the Motor Challenge program in 1993, the idea behind an Excellence Partner program was conceived so as to recognize those industrial companies that are demonstrating excellence in motor systems management. Since then, the Excellence Partner program has been further developed to support those Motor Challenge Partners that are committing to the continual improvement of motor systems management practices. Similar to the Showcase Demonstrations, companies such as 3M and DuPont are looking for an external organization (DOE) to assist them in bringing a motor systems management initiative into the fold to enhance their existing internal corporate energy -management programs. Surprisingly, most companies have not as yet been able to develop a strategic motor systems management program that would integrate all the individual resources and expertise within a company that are necessary to fully capture motor systems efficiency and productivity opportunities. The Motor Challenge Excellence Partner program will provide tailored resources to companies to help them implement their respective plans. The results, best practices, policies adopted by the Excellence Partners will be highlighted by DOE to encourage other companies to do likewise. Here again, DOE is playing a unique role that no other organization could as effectively and legitimately facilitate on a nationwide basis without having a some type of vested interest to do so.

Q350. Page 505 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following Motor Challenge performance metrics for FY 1995 and FY 1996:

Measure:

	1995	1996
Total Partners	**1,000**	**2,000**
Excellence Partners	**--**	**10**
Allied Partners	**--**	**50**
Showcase Demonstrations Completed	**--**	**10**
Annual info recipients	**5,000**	**10,000**

Q350a. Please provide detailed documentation for each of these claimed performance metrics in FY 1995 and FY 1996, including identification of each "Total Partner", "Excellence Partner", and "Allied Partner" and DOE funding provided to each such partner in FY 1995 and FY 1996.

A350a. **Total Motor Challenge Partners:**

- At the end of FY 1995 there were 1,054 total Motor Challenge partners. See attachment following the answer to Q350b.

- Currently (end of April, 1996) there are 1,301 Motor Challenge partners. The list of partners that have joined in FY 1996 is shown in attachment 350b. The goal of reaching 2,000 total partners by the end of FY 1996 is achievable, due to two factors: (1) the number of companies joining the program recently is accelerating (about 100 per month); and (2) planned recruitment efforts later in the fiscal year with "end user" partner corporations to enlist their individual field sites into the program should also accelerate partner recruitment.

Motor Challenge partners receive no financial assistance from DOE. Partners receive technical assistance, Motor Challenge products, participate in Motor Challenge events and activities, and are recognized for their individual or collective achievements.

Excellence Partners: The Excellence Partnership is the newest and most developing part of the Motor Challenge program. DOE has held a few planning meetings with key industrial end-user partner companies in developing the Excellence Partner program. Currently, DuPont and 3M are moving ahead to develop a corporate plan as one necessary part of qualifying to be an Excellence Partner. Their plans should be done by June, 1996. At that time (submitting of plans), DuPont and 3M will be the first Motor Challenge Excellence Partners. Simultaneously, DOE has received high interest from many other companies to be Excellence Partners (e.g., Peabody Holding Co., Bethlehem Steel, Johnson & Johnson, Alumax Corp, Lockheed Martin, James River Paper, ICI, etc.). Accordingly, DOE will work with these companies and others to pursue appropriate Excellence Partner plans to meet the goal of enlisting 10 Excellence Partners by the end of FY 1996.

Motor Challenge Excellence Partners will receive no financial assistance from DOE. They will receive tailored Motor Challenge technical assistance and resources in return for their commitment to, and leadership in, improving motor system management practices.

Allied Partners: DOE has held two Allied Partner workshops this year (March/Baltimore, MD; April/Cleveland, OH) and plans are to hold four more similar workshops throughout the country this fiscal year. These workshops are intended to educate interested non-end-user companies and organizations about the Allied Partner program: what is an Allied Partner(AP)?, what does an AP have to do?, and what does DOE do for an AP?, etc. So far, interest has been very high from prospective APs. The following list provides the status of enlisting companies/organizations into the Motor Challenge Allied Partner program:

There are three current Allied Partners (completed Action Plans), they are:

- Electrical Apparatus Service Association (EASA)
- Baltimore Gas and Electric
- Union Electric (Kansas City, MO area)

There are two companies that are completing their applications and plans:

- Lower Colorado River Authority (who serve 44 public/municipal utilities which provide energy efficiency services to customers)
- Kirby Risk Electric Motor Repair (Cleveland, Ohio)

Several other companies have expressed interest in the Allied Partner Program:

- Consumers Power, Grand Rapids, MI
- Pneumatech, Inc./ConserAIR, Kenosha, WI
- Binkleman, Bauer, Wenner, Toledo, OH
- Consolidated Electrical Distributors, Cleveland, OH
- Volland Electric Equipment
- Bearings, INC.
- Karnan Industrial
- Electric Motor Supply, Inc.
- Motion Industries
- Southern Minnesota Municipal Power Agency, Rochester, MN
- Bartosh Distributing Company, Inc.
- Bob Green Electrical
- Bonneville Power Administration
- Compressed Air and Gas Institute
- Dixie Bearings
- Grainger
- Medina Electric Cooperative
- New York Power Authority
- Otter Tail Power Company

- New York State Electric and Gas Corporation
- Tucson Electric
- Northern States Power Company
- Southwestern Public Service
- The Electric Motor Repair Company
- Wolters Motors and Drives
- Holt Electric Motor Company
- Houston Armature Works
- Portland General Electric
- Northwest Public Service
- Central and Southwest Services
- Cincinnati Gas and Electric Company
- ENBERTECH (sub. of Louisville Gas and Electric)
- Empire District Electric Company
- PECO Energy
- Illinois Power
- Gatewood Electric
- Electrical Equipment Company
- Energy Systems Engineering, Inc.
- Apparatus Repair and Engineering
- AA Anderson (industrial pumps and engineering)
- Commonwealth Edison
- B & B Electric Motor Company
- Electric Enterprise Incorporated
- Intermountain Electric
- R Scheinert & Son (Elect. and Mech. sales and service)
- Vanderwinde Electric Corp., (Motor services)

Motor Challenge Allied Partners will receive no financial assistance from DOE. They will receive tailored Motor Challenge technical assistance and resources in return for their efforts to deliver a comprehensive array of Motor Challenge products and training curriculum to industrial end-users.

Showcase Demonstrations: The Lockheed Martin Showcase has been completed. Nine other Showcases will follow, and therefore, ten projects will be completed by the end of FY 1996. The nine other sites are:

2. 3M Company, St. Paul, MN
3. Peabody Holding Company, Marissa, IL
4. Alumax, Goosecreek, SC
5. City of Milford, CT
6. Eastman Kodak, Rochester, NY
7. Greenville Tubing Corp., Clarksville, AR
8. OXY USA. multiple sites, KS

9. General Motors, Pontiac, MI
10. ENRON Corp., Hubbard, IA

DOE provides no direct financial assistance to the Showcase Demonstrations teams, but provides technical assistance, an independent performance validation, develops a case study, and provides recognition for each project.

Annual Information Recipients: Information dissemination is an important function of the Motor Challenge program. People in industry are persistently searching for new types of reliable and accurate information (from independent sources) to assist them in their design, purchase, and specification decision-making. Information dissemination in the Motor Challenge program is varied. The following breaks down the types of information dissemination provided, to who, where, and to approximately how many people:

Information Clearinghouse: To date the Motor Challenge Information Clearinghouse has serviced 2,200 people over 6 months. Therefore, over 4,000 to 5,000 people should be serviced for FY 1996.

Partner communications:

Description	Who, Where	How Many
Turning Point Newsletter (general program information)	All Partners, All Sites: Other stakeholders on mailing list	1,300 partner companies (4,000 people); plus 2,000 other people; issued quarterly
Partner Bulletin (specific partner information	All Partners, All Sites	1,300 partners companies (4,000 people); issued 8 times per year

Trade Shows, Conferences, Meetings: These events Motor Challenge has participated in, or will provide program representation in FY 1996. A display of program information to inform event participants about the program was, or will be provided at each event.

Description	Who, Where	How many people have or will have received info. In FY96
American Institute of Plant Engineers	Industrial engineers, Portland, OR	200 people
World Energy Engineering Conference	Energy professionals, Atlanta, GA	500 people
Electrical Apparatus Service Association Annual Convention	Motor repair service companies and other suppliers, Phoenix, AZ	300 people
Plant Engineering Show	General industry, Chicago, IL	500 people
Electro Tech	Utilities, St. Louis, MO	200 people
Global Con	General industry, Denver, CO	300 people
Industrial Energy Expo	Industrial energy managers, Houston, TX	75 people
Carolina Plant Engineering Show	Industrial plant engineers, Greenville, SC	300 people
Refinery and Petrochemical Plant Maintenance Show	Refinery plant engineers, Nashville, TN	300 people
Edison Electric Institute Transforming Tradition Conference	Utilities, Dallas, TX	150 people
American Water Works Association Annual Convention	Municipalities. Toronto, Canada	500 people

Description	Who, Where	How many people have or will have receivedinfo. In FY96
EEC Industrial Energy Expo	Industrial energy managers, Milwaukee, WI	500 people
Institute of Electrical and Electronic Engineers Industry Applications Society	Industrial electrical engineers, San Diego, CA	500 people
National Industrial Efficiency Conference	Industrial energy managers Somerset, NJ	500 people

Motor Challenge Workshops and Training Sessions: These workshops and training events Motor Challenge has, or will sponsor in FY 1996.

Description	Who, Where	How many people received info
Regional (California/West Coast) motor systems training workshops	Motor Challenge, California Energy Commission, Pacific Gas & Electric, San Diego Gas & Electric, others. All over California	600 people have been trained so in FY 1996 through 5 workshops. 600 more will be trained this year.
Motor Master + software training	Motor Challenge Partners Atlanta, Philadelphia, Chicago, Kansas City, Oakland, Houston	Up to 100 for each session.
Midwest Motor System Consortium Training Workshop for Southern - Minnesota Municipal Power Agency in St. Paul, MN	Motor Challenge, and Partners: Baldor Electric, Reliance Electric, Grainger, Flowcare Engineering	Up to 100 people.
Allied Partner Workshops	Motor Challenge, Potential Allied Partners Baltimore, Cleveland Houston, Oakland., Atlanta, Chicago	60 people attended each of the Baltimore and Cleveland workshops. Similar attendance is expected at the other 4 Workshops.

Q350b. Please describe each "Showcase Demonstration" to be completed in FY 1996, including DOE and private sector funding, by performer, for each.

A350b. Ten Showcase Demonstrations are scheduled to be completed by the end of FY 1996. DOE is funding $1.5 million in FY 1996 to support these projects and others through targeted technical assistance to each team; development of an independent performance validation and project case study documentation for each project; and workshops that DOE sponsors for all project teams. Again, DOE provides no direct financial assistance to the project teams. The projects are summarized as follows:

Showcase Demonstration Project, Location	Description	Private Sector Investment, $	System Energy Savings (%)	Energy Savings, $/year
Lockheed Martin Burlington, VT	Optimization of the plating operation ventilation system	$99,000	32% on one process	$68,000
3M Company St. Paul, MN	Comprehensive motor and drive system modification and replacement throughout their corporate headquarters lab facilities.	$1,845,000	6% on entire headquarter lab facility complex	$800,000

Showcase Demonstration Project, Location	Description	Private Sector Investment, $	System Energy Savings (%)	Energy Savings, $/year
Peabody Holding Company Marissa, IL	Retrofit of pump system in coal handing facility with modified pump impeller, energy efficient motor, and new belt drive.	$20,000	15% on one pump system	$7,000
Alumax Aluminum Co. Goosecreek, SC	Process fan system optimization (four large fans).	$20,000	25% on fan system	$65,000
City of Milford Municipality Milford, CT	System optimization of one sewage lift station.	$20,000	20% on sewage lift station	$5,000
Eastman Kodak Rochester, NY	A variety of motor system modifications. Showcase will focus on site's approach to capturing motor system efficiency opportunities with minimal capital requirements.	$5.0 million	5%	$2.4 million
Greenville Tubing Corp. Clarksville, AR	Installation of a vector drive to control the tube drawing machine in a much more efficient and productive manner.	$37,000	25% on tube drawing machine	$35,000
OXY USA Hayes, KS	Installation of electrical and mechanical modifications to oil field beam pumps.	$25,000	25%	$7,900
General Motors Pontiac, MI	Installation of new pump systems (pumps and energy-efficient motors).	$30,000	60% on water pumping station	$27,000
ENRON Corp. Hubbard, IA	Installation of new electric motor drive for compressor on natural pipeline compression station. Replace out older, less efficient internal combustion engine.	Electric drive is $2.4 million less in cost than gas turbine.	2% in prime energy savings	$48,000 in operating costs savings

Attachment 350 (a):

MOTOR CHALLENGE FY1995 PARTNERS

COMPANY	STATE	CITY
3M	MN	Saint Paul
A&C Enercom	GA	Atlanta
A.I.M. Energy	DC	Washington
A.N.A. Hotel S.F.	CA	San Francisco
ABB Industrial Systems inc.	WI	New Berlin
Admag	CA	Fullerton
Aerovox Group	MA	New Bedford
Agralite Cooperative	MN	Benson
Airforce Civil Engineering Support Age	FL	Tyndall AFB
Airport Authority of Washoe County	NV	Reno
Ajax Electric Motor Corporation - HQ	NY	Rochester
Ajax Electric Motor Corporation - Lake	MO	Lake St. Louis
Alameda Bureau of Electricity	CA	Alameda
Alaska Division of Energy	AK	Anchorage
Alexandria Sanitation Authority	VA	Alexandria
Allegheny Electric Cooperative	PA	Harrisburg
Alliance to Save Energy	DC	Washington
Allied Electric Motor Service	CA	Fresno
Allied Signal	MO	Kansas City
Alternative Energy Corporation	NC	Raleigh
Alternative Energy Systems Consulting	CA	Carlsbad
Altus Group The	TX	Arlington
Alumax of South Carolina	SC	Goose Creek
American Council for an Energy Efficie	DC	Washington
American Home Products Corporation	WI	Madison
American Iron and Steel Institute	DC	Washington
American Portland Cement Alliance	DC	Washington
American Public Power Association	DC	Washington
Amoco Production Co. Prentice O.C.	TX	Brownfield
Anchor Glass Container Corp	FL	Tampa
Andrews AFB - 89 SPTG/CECE	MD	Andrews AFB
ANG/CECC	ND	Minot
Ankeny Community Schools	IA	Ankeny
Anker Energy Corporation	WV	Morgantown
Apparatus Repair & Engineering	MD	Hagerstown
Appropriate Technology Of Hawaii	HI	Honolulu
Architechnology	NH	Sanbornton
ARCO Products Company	CA	Carson
Arizona State University (EADC)	AZ	Tempe
Armatures	MI	Farmington Hills
Assoc. of Prof. Energy Managers - OR	OR	Salem
Assoc. of Prof. Energy Managers - WA	WA	Bellevue
Associated Air Products of Palm Beach	FL	Riviera Beach
ATA	IN	South Bend
Atlanta Armature Works	GA	Atlanta
Atlantic City Airport FAA Tech Center	NJ	Atlantic City
Atlantic Electric	NJ	Pleasantville
Autolutions	MI	Westland
Automation Engineering	IN	Ft. Wayne
Ayres Consulting	IA	Des Moines
Azusa Light & Water Department	CA	Azusa
B&B Electric Motor Company	KS	Wichita
Baldor Electric Company - Cincinnati	OH	Cincinnati
Baldor Electric Company - HQ	AR	Fort Smith
Bartosh Dist Company	TX	Austin
BASF Corporation	NJ	Mount Olive
Baskerville-Donovan	FL	Pensacola
Bearings	AR	Little Rock
Bearings	CT	Hartford
Bearings	CT	S. Windsor
Bearings	CT	Waterbury
Bearings	DE	New Castle
Bearings	DE	Wilmington
Bearings	FL	Orlando
Bearings	ID	Lewiston
Bearings	IN	Columbus
Bearings	IN	Evansville
Bearings	IN	Fort Wayne
Bearings	IN	Indianapolis
Bearings	IN	Indianapolis
Bearings	IN	Kokomo
Bearings	IN	Lafayette
Bearings	IN	Marion
Bearings	IN	Muncie
Bearings	IN	Portage
Bearings	IN	Richmond
Bearings	IN	Terre Haute
Bearings	KS	Kansas City
Bearings	KY	Florence
Bearings	MA	Avon
Bearings	MA	Chicopee
Bearings	MA	Wilmington

Bearings	MA	Worcester
Bearings	MA	Worcester
Bearings	MD	Baltimore
Bearings	MD	Salisbury
Bearings	ME	E. Millinocket
Bearings	ME	Hermon
Bearings	ME	Livermore Falls
Bearings	MT	Butte
Bearings	MT	Kalispell
Bearings	MT	Missoula
Bearings	NH	Dover
Bearings	NH	Manchester
Bearings	NJ	Rahway
Bearings	NJ	Totowa
Bearings	NJ	Trenton
Bearings	OH	Akron
Bearings	OH	Bedford
Bearings	OH	Canton
Bearings	OH	Chillicothe
Bearings	OH	Cincinnati
Bearings	OH	Cleveland
Bearings	OH	Columbus
Bearings	OH	Dayton
Bearings	OH	Elyria
Bearings	OH	Hamilton
Bearings	OH	Lima
Bearings	OH	Mansfield
Bearings	OH	Marion
Bearings	OH	Middletown
Bearings	OH	New Philadelphia
Bearings	OH	Newark
Bearings	OH	Painesville
Bearings	OH	Sandusky
Bearings	OH	Sidney
Bearings	OH	South Point
Bearings	OH	Springfield
Bearings	OH	Steubenville
Bearings	OH	Toledo
Bearings	OH	Warren
Bearings	OH	Youngstown
Bearings	OH	Zanesville
Bearings	OK	Oklahoma City
Bearings	OK	Tulsa
Bearings	OR	Albany
Bearings	OR	Bend
Bearings	OR	Clackamas
Bearings	OR	Coos Bay
Bearings	OR	Eugene
Bearings	OR	Medford
Bearings	OR	Portland
Bearings	OR	Roseburg
Bearings	OR	Salem
Bearings	OR	Tualatin
Bearings	PA	Allentown
Bearings	PA	Butler
Bearings	PA	Center Valley
Bearings	PA	Duncansville
Bearings	PA	Duncansville
Bearings	PA	Duquesne
Bearings	PA	Erie
Bearings	PA	Greencastle
Bearings	PA	Harrisburg
Bearings	PA	Johnstown
Bearings	PA	Lancaster
Bearings	PA	Monessen
Bearings	PA	Norristown
Bearings	PA	Philadelphia
Bearings	PA	Pittsburgh
Bearings	PA	Reading
Bearings	PA	Rochester
Bearings	PA	Wilkes-Baird
Bearings	PA	Williamsport
Bearings	PA	York
Bearings	RI	Warwick
Bearings	TN	Nashville
Bearings	TX	Amarillo
Bearings	TX	Arlington
Bearings	TX	Austin
Bearings	TX	Brownwood
Bearings	TX	Conroe
Bearings	TX	Dallas
Bearings	TX	Deer Park
Bearings	TX	Eagle Lake
Bearings	TX	Fort Worth
Bearings	TX	Garland
Bearings	TX	Houston
Bearings	TX	Longview
Bearings	TX	Longview
Bearings	TX	Lutlon
Bearings	TX	McAllen

Bearings	TX	Nederland
Bearings	TX	Odessa
Bearings	TX	Paris
Bearings	TX	Rockdale
Bearings	TX	Sherman
Bearings	TX	Stafford
Bearings	TX	Sweetwater
Bearings	TX	Temple
Bearings	TX	Texarkana
Bearings	TX	Texas City
Bearings	TX	Tyler
Bearings	TX	Waco
Bearings	TX	Waxahachie
Bearings	VA	Alexandria
Bearings	VT	Rutland
Bearings	WA	Aberdeen
Bearings	WA	Bellingham
Bearings	WA	Burlington
Bearings	WA	Centralia
Bearings	WA	Everett
Bearings	WA	Kent
Bearings	WA	Longview
Bearings	WA	Olympia
Bearings	WA	Pasco
Bearings	WA	Seattle
Bearings	WA	Spokane
Bearings	WA	Tacoma
Bearings	WA	Vancouver
Bearings	WA	Yakima
Bearings	WV	Beckley
Bearings	WV	Bluefield
Bearings	WV	Charleston
Bearings	WV	Charleston
Bearings	WV	Fairmont
Bearings	WV	Parkersburg
Bearings	WV	Wheeling
Bearings	WV	Williamson
Berexco	KS	Wichita
Bethlehem Steel Corporation	PA	Bethlehem
BGK Inc	IL	Glenview
Big Rivers Electric Co-Op	KY	Henderson
Big Woods Electric Motor Inc	ND	Wahpeton
Birclar Electric & Machine	MI	Romulus
Black & Veatch	MO	Kansas City
Black & Veatch	MI	Ann Arbor
Blanchard Electric Incorporated	MA	Whitman
Bluesky Tech Services	MT	Elliston
Bob Brown & Associates	WI	New Berlin
Bob Green Electrical	CO	Englewood
Boeing Company	WA	Seattle
Bonneville Power Administration	OR	Portland
Borealis Technical	OH	Hillsboro
Brabazon Pump & Compressor	WI	Green Bay
Brithinee Electric	CA	Colton
Brook Hansen Inc	IL	Arlington Heights
Bruening Bearings	IL	Decatur
Bruening Bearings	IL	Granite City
Bruening Bearings	KY	Bowling Green
Bruening Bearings	KY	Corbin
Bruening Bearings	KY	Lexington
Bruening Bearings	KY	Louisville
Bruening Bearings	KY	Owensboro
Bruening Bearings	KY	Paducah
Bruening Bearings	KY	Richwood
Bruening Bearings	KY	Russellville
Bruening Bearings	KY	Walton
Bruening Bearings	MO	Fenton
Bruening Bearings	MO	Jefferson City
Bruening Bearings	MO	St Louis
Bruening Bearings	NY	Albany
Bruening Bearings	NY	Big Flats
Bruening Bearings	NY	Buffalo
Bruening Bearings	NY	Falconer
Bruening Bearings	NY	Plattsburgh
Bruening Bearings	NY	Queensbury
Bruening Bearings	NY	Rochester
Bruening Bearings	NY	Syracuse
Bruening Bearings	NY	Tonawanda
Bruening Bearings	NY	Vestal
Buckeye Pipe Line Company	PA	Emmaus
Buckeye Power	OH	Columbus
Burlington Electric Department	VT	Burlington
Business Council For A Sustainable Ene	DC	Washington
Butterworth Hospital	MI	Grand Rapids
CA Dept of Water Resources	CA	Oroville
Caer Engineers	CO	Golden
Calhoon Marine Engineering School	MD	Easton
California Energy Commission	CA	Sacramento
Cannady & Associates	MI	Holland
Caprock Industries Inc	TX	Gruver

Carolina Consulting Group	NC	Garner
Carolina Electric Cooperatives	NC	Raleigh
Cascade Controls Northwest	OR	Portland
Cascio Bechir Engineers	CT	North Haven
Central & South West Services	TX	Dallas
Central Community College	NE	Columbus
Central Maintenance	NY	Rochester
CEP Sales Company Inc.	VA	Richmond
Certainteed Corporation	PA	Blue Bell
Champion International Corporation	OH	Hamilton
Chancellor Industries	CA	Poway
Chase Dynamics	CA	Tarzana
Chemical Manufacturers Association	DC	Washington
Chevron Pipe Line Company	ID	Boise
Chevron U S A	CA	Richmond
Chevron U S A Products Company	CA	San Francisco
Chillicothe Municipal Utilities	MO	Chillicothe
Cincinnati Electric Inc.	OH	Cincinnati
City & County Of San Francisco	CA	San Francisco
City Of Aberdeen	WA	Aberdeen
City Of Abilene	TX	Abilene
City of Austin ECSD	TX	Austin
City Of Enid	OK	Enid
City of Long Beach - SERRF	CA	Long Beach
City of Milford/Wastewater Division	CT	Milford
City of Moline-Water Plant	IL	Moline
City Of Philadelphia Municipal Energy	PA	Philadelphia
City of Sacramento	CA	Sacramento
City of Salem	OR	Salem
City of Wahoo	NE	Wahoo
City University of New York	NY	New York
Clark Electric Motor Co.	MT	Billings
Cleveland Electric Company	GA	Atlanta
Climate Makers Inc	MN	N. St. Paul
Clow-Rodgers	AL	Birmingham
Coats North America	GA	Toccoa
Colvin Engineering Associates	UT	Salt Lake City
Commercial Electric Products Corporati	OH	Cleveland
Concept Energy Systems Inc. - CES	GA	Clarkston
Condo Electric & Industrial Supply	FL	Hialeah
Conrey Electric Inc.	OR	Portland
Consol Coal Group	PA	Pittsburgh
Consolidated Papers	WI	Wisconsin Rapids
Consortium for Energy Efficiency	MA	Boston
Consumers Power Company	MI	Jackson
Cooper Communications	NJ	South Orange
Cornell Pump Company	OR	Portland
Corporation For Ohio Appalachian Devel	OH	Athens
County of Santa Cruz	CA	Santa Cruz
Cray Research Inc.	WI	Chippewa Falls
Curwood	WI	Oshkosh
D.L. Hermanson & Associates - Baldor	OR	Portland
Dairy Maid Dairy Inc	MD	Frederick
Dakota Electric Association	MN	Farmington
Dakota Heartland Health System	ND	Fargo
Dakota Hospital	ND	Fargo
Darby Electric Company	SC	Anderson
DART Container	TX	Waxahachie
DAX Industries	TX	Houston
Dayton Power and Light Company	OH	Dayton
Dayton Products Division-Emerson Elect	MO	Saint Louis
Decatur Industrial Electric	IL	Decatur
Deep South Aqua Farms	LA	Gretna
DeLeuw Cather Co	DC	Washington
Delta Motor Company	CA	Signal Hill
Delta-Montrose Electric Association	CO	Delta
Demand Management Institute	MA	Newton
Demand Side Services	VT	Stowe
Dennis K. Burke Inc.	MA	Chelsea
Department Of Water Resources	CA	Chico
Dept of Army/DLP FLC & POM	CA	Monterey
Dept of Electrical & Computer Eng	FL	Gainesville
Dever Company	TN	Memphis
Dip-Proofing Technologies	CA	West Los Angeles
Diversified Mechanical Sales	FL	Orlando
Dixie Bearings	AL	Anniston
Dixie Bearings	AL	Birmingham
Dixie Bearings	AL	Decatur
Dixie Bearings	AL	Demopolis
Dixie Bearings	AL	Dothan
Dixie Bearings	AL	Gadsden
Dixie Bearings	AL	Hueytown
Dixie Bearings	AL	Mobile
Dixie Bearings	AL	Montgomery
Dixie Bearings	AL	Scottsboro
Dixie Bearings	AR	Camden
Dixie Bearings	AR	Crossett
Dixie Bearings	AR	De Queen
Dixie Bearings	AR	Fort Smith
Dixie Bearings	AR	Hot Springs

Dixie Bearings	AR	Jonesboro	Dixie Bearings	MS	Hattiesburg
Dixie Bearings	AR	Little Rock	Dixie Bearings	MS	Jackson
Dixie Bearings	AR	Pine Bluff	Dixie Bearings	MS	Tupelo
Dixie Bearings	AR	Stuttgart	Dixie Bearings	NC	Arden
Dixie Bearings	FL	Bradenton	Dixie Bearings	NC	Asheville
Dixie Bearings	FL	Cantonment	Dixie Bearings	NC	Charlotte
Dixie Bearings	FL	Fort Pierce	Dixie Bearings	NC	Charlotte
Dixie Bearings	FL	Jacksonville West	Dixie Bearings	NC	Coreenville
Dixie Bearings	FL	Jacksonville West	Dixie Bearings	NC	Durham
Dixie Bearings	FL	Jacksonville	Dixie Bearings	NC	Eden
Dixie Bearings	FL	Lakeland	Dixie Bearings	NC	Fayetteville
Dixie Bearings	FL	Largo	Dixie Bearings	NC	Gastonia
Dixie Bearings	FL	Mulberry	Dixie Bearings	NC	Greensboro
Dixie Bearings	FL	Orlando	Dixie Bearings	NC	Greenville
Dixie Bearings	FL	Palatka	Dixie Bearings	NC	Hickory
Dixie Bearings	FL	Tampa	Dixie Bearings	NC	Hickory
Dixie Bearings	GA	Albany	Dixie Bearings	NC	Monroe
Dixie Bearings	GA	Athens	Dixie Bearings	NC	Raleigh
Dixie Bearings	GA	Atlanta	Dixie Bearings	NC	Washington
Dixie Bearings	GA	Augusta	Dixie Bearings	NC	Wilmington
Dixie Bearings	GA	Brunswick	Dixie Bearings	NC	Winston-Salem
Dixie Bearings	GA	Cartersville	Dixie Bearings	SC	Anderson
Dixie Bearings	GA	College Park	Dixie Bearings	SC	Charleston
Dixie Bearings	GA	Columbus	Dixie Bearings	SC	Charleston
Dixie Bearings	GA	Conyers	Dixie Bearings	SC	Columbia
Dixie Bearings	GA	Doraville	Dixie Bearings	SC	Florence
Dixie Bearings	GA	Dublin	Dixie Bearings	SC	Greenville
Dixie Bearings	GA	Gainesville	Dixie Bearings	SC	Greenwood
Dixie Bearings	GA	LaGrange	Dixie Bearings	SC	Spartanburg
Dixie Bearings	GA	Macon	Dixie Bearings	SC	Union
Dixie Bearings	GA	Savannah	Dixie Bearings	TN	Chattanooga
Dixie Bearings	GA	Smyrna	Dixie Bearings	TN	Cleveland
Dixie Bearings	GA	Thomasville	Dixie Bearings	TN	Columbia
Dixie Bearings	GA	Valdosta	Dixie Bearings	TN	Jackson
Dixie Bearings	GA	Vienna	Dixie Bearings	TN	Kingsport
Dixie Bearings	LA	Alexandria	Dixie Bearings	TN	Knoxville
Dixie Bearings	LA	Baton Rouge	Dixie Bearings	TN	Memphis
Dixie Bearings	LA	Harahan	Dixie Bearings	TN	Murfreesboro
Dixie Bearings	LA	Shreveport	Dixie Bearings	TN	Nashville
Dixie Bearings	LA	Sulphur	Dixie Bearings	VA	Covington
Dixie Bearings	LA	West Monroe	Dixie Bearings	VA	Danville
Dixie Bearings	MS	Columbus	Dixie Bearings	VA	Hampton
Dixie Bearings	MS	Corinth	Dixie Bearings	VA	Lynchburg
Dixie Bearings	MS	Greenville	Dixie Bearings	VA	Norfolk
Dixie Bearings	MS	Grenada	Dixie Bearings	VA	Richmond

Dixie Bearings	VA	Roanoke
Dixie Bearings	VA	Vansant
Dixie Bearings	VA	Waynesboro
Doane Products Company	MO	Joplin
Domtar	TX	Sweetwater
Dow Chemical Company	MI	Midland
Dreisilker Electric Motors	IL	Glen Ellyn
DSMI	CO	Englewood
Dunn's Electric Motor Service	CA	Sacramento
DYN Corporation	KS	Overland Park
E G & G Florida	FL	Kennedy Space Cente
E. I. du Pont de Nemours & Company	DE	Wilmington
East Jordan Iron Works	MI	East Jordan
Eastland Industries	IL	Hillside
Eastman Kodak Company - Site Services	NY	Rochester
Echelmeier Company	MO	Chesterfield
EcoTech/RAM-Q	NJ	Manasquan
Ecusta-P.H. Glatfelter Co	NC	Pisgah Forest
Edan Engineering Corporation	WA	Vancouver
Edison Electric Institute	DC	Washington
EEMSCO	IL	Evansville
Electric League of the Northwest	WA	Bellevue
Electric Maintenance Service Co.	CT	Bridgeport
Electric Motor & Supply Inc.	PA	Altoona
Electric Motor Repair Company	MD	Baltimore
Electric Motor Supply	MO	Joplin
Electric Power Research Institute	CA	Palo Alto
Electrical Apparatus Service Associati	MO	St. Louis
Electrical Equipment Company	CA	Petaluma
Electricity Generating Authority of Th	NY	Nonthaburi
Electrification Council	DC	Washington
Electro-Mec	PA	Indiana
Electrodynamics Associates	IL	Rockford
Electromotion	MI	Highland Park
Eli Lilly & Co. LTC Utility Engineerin	IN	Indianapolis
Emerald People's Utility District	OR	Eugene
Emerson Electric	MO	St. Louis
Emerson Swan	MA	Randolph
Empire District Electric Company	MO	Joplin
EMS	CT	Wallingford
Energetics	MD	Columbia
Energy Affairs Administration	PR	Puerta de Tierra
Energy Affairs Administration	PR	Puerta de Tierra
Energy Analysis and Management	NE	Lincoln
Energy Conservation Contractors	GA	Atlanta
Energy Conservation Management	MD	Baltimore
Energy Group	AZ	Chandler
Energy Investment	MA	Boston
Energy Management Inc.	VT	South Burlington
Energy Masters Corp.	KS	Overland Park
Enersave	NY	New York
Engineered Services	PA	Emmaus
Engineered Software	WA	Olympia
Enron Corporation	DC	Washington
Entergy Corp	MN	St. Paul
Entergy Corp.	LA	New Orleans
Eugene Water & Electric Board	OR	Eugene
Eutectic Corporation	TN	Antioch
Evans Electric Motor Centers Inc.	OK	Oklahoma City
EWS Corporation	NY	West Shokan
Exxon Corporation	TX	Irving
Facility Management Consulting Service	OR	Canby
Fairmount Minerals	IL	Wedron
Fenkhauser Company - Baldor	OH	Cuyahoga Heights
Federated Rural Electric	MN	Jackson
First (1st) Mechanical	CA	San Diego
Future Concepts	TX	San Angelo
Fleet Companies	NY	Harrison
Florida Energy Extension Service	FL	Gainesville
Florida Power & Light Company	FL	Miami
Floridin Company -Quincy	FL	Quincy
Fluor Daniel (NPOSR-CUW)	WY	Casper
FMSM Architects & Engineers	NM	Albuquerque
Ford Motor Co - Milan	MI	Milan
Ford Motor Company	MI	Dearborn
Ford Motor Company - Van Dyke	MI	Sterling Heights
Fort Collins Light & Power	CO	Fort Collins
Fort Riley Public Works Dept	KS	Fort Riley
Fox Bros Electric Motor Service	TN	Murfreesboro
Frank J. Renick Associates	NJ	Hawthorne
Fuller Electric Motor Svc	FL	Jacksonville
G-N Electric Company	IL	Chicago
G.J. Bender	NJ	Kenilworth
Gary Diddy Company - Baldor	CO	Denver
Gates Rubber Company	CO	Denver
General Electric ASD-EMP	IN	Mt. Vernon
General Electric Company	IN	Indianapolis
General Electric Company - HQ	IN	Fort Wayne
General Motors Corporation	MI	Detroit
Geomet Technologies	MD	Germantown

Georgia-Pacific Corp - Ashdown	AR	Ashdown
Georgia-Pacific Corp - Crossett	AR	Crossett
Georgia-Pacific Corp - Palatka	FL	Palatka
Georgia-Pacific Corp - (Chem) Atlant	GA	Atlanta
Georgia-Pacific Corp - (Pgk) Atlanta	GA	Atlanta
Georgia-Pacific Corp - (Wd Prod) At	GA	Atlanta
Georgia-Pacific Corp - Brunswick	GA	Brunswick
Georgia-Pacific Corp - Cedar Springs	GA	Cedar Springs
Georgia-Pacific Corp - Gary	IN	Gary
Georgia-Pacific Corp - Port Hudson	LA	Zachary
Georgia-Pacific Corp - Woodland	ME	Woodland
Georgia-Pacific Corp - Kalamazoo	MI	Kalamazoo
Georgia-Pacific Corp - Leaf River	MS	New Augusta
Georgia-Pacific Corp - Monticello	MS	Monticello
Georgia-Pacific Corp - Plattsburgh	NY	Plattsburgh
Georgia-Pacific Corp - Toledo	OR	Toledo
Georgia-Pacific Corp - Big Island	VA	Big Island
Georgia-Pacific Corp - Bellingham	WA	Bellingham
Georgia-Pacific Corp - Nekoosa	WI	Port Edwards
Georgia-Pacific Corp - Port Edwards	WI	Port Edwards
GHR Consulting Services	PA	Horsham
GHT Limited	VA	Arlington
Gibson Electric Motors Sales & Service	MS	Pascagoula
Giddings & Lewis Casting Technologies	MI	Menominee
Giffels Hoyem Basso	MI	Troy
Gil Friend & Associates	CA	Berkeley
GIW Industries	GA	Grovetown
Goose Creek WWTP	PA	Westchester
Gould's Pump	NY	Seneca Falls
Governor's Office of Energy & Communit	NH	Concord
Graham Company	WI	Milwaukee
Grainger	IL	Lincolnshire
Grays Harbor PUD	WA	Aberdeen
Great Lakes Controlled Energy Company	IL	Elk Grove Village
Green Technologies	CO	Boulder
Greenville Tube Corporation	AR	Clarksville
Guardian Industries	TX	Corsicana
Gulf Power Company	FL	Pensacola
Gundersen Clinic	WI	LaCrosse
H & N Electric	WA	Pasco
H & W Power Sales	TX	Houston
H&R 1871	MA	Gardner
H.M Bailey Co	NJ	Collingswood
Halligan & Associates	IL	Chicago
Halmar Robicon Drives Group	PA	Pittsburgh
Hayden Electric	AK	Anchorage
Hellmer & Medved Engineering	KS	Mission
Hermitage Tech Center	VA	Richmond
Hickman Air Force Base	HI	Hickam AFB
Hoechst Celanese Corporation	TX	Dallas
HOK Architects	SC	Greenville
Holnam Inc	MI	Dundee
Holt Electric Motor Company	WI	Hartland
Holy Cross Electric Association	CO	Glenwood Springs
Holzer Energy Management Company	MD	Laurel
Honeywell - DMC Services	AR	North Little Rock
Hormel Foods Corporation - Stockton CA	CA	Stockton
Hormel Foods Corporation - Tucker GA	GA	Tucker
Hormel Foods Corporation - Algona IA	IA	Algona
Hormel Foods Corporation - Davenport I	IA	Davenport
Hormel Foods Corporation - Knoxville I	IA	Knoxville
Hormel Foods Corporation - Rochelle IL	IL	Rochelle
Hormel Foods Corporation - Wichita KS/	KS	Wichita
Hormel Foods Corporation - Austin MN	MN	Austin
Hormel Foods Corporation - Wilmar MN/J	MN	Wilmar
Hormel Foods Corporation - Hollandale	MS	Hollandale
Hormel Foods Corporation - Fremont NE	NE	Fremont
Hormel Foods Corporation - Oklahoma Ci	OK	Oklahoma City
Hormel Foods Corporation - Houston TX	TX	Houston
Hormel Foods Corporation - Beloit WI	WI	Beloit
Houston Armature Works	TX	Houston
Hugh J Cullen Associates	NJ	Neptune
Huls America	NJ	Piscataway
Huntsville Hospital	AL	Huntsville
Hydraulic Institute	NJ	Parsippany
Hydro Power	IN	Indianapolis
IBT	AR	Ft. Smith
IBT	KS	Shawnee Mission
IBT	MO	St. Louis
IBT	KS	Wichita
ICF Kaiser Hanford Company - Energy Mg	WA	Richland
ICF	VA	Fairfax
ICI Films Inc	VA	Hopewell
ICOM Inc	PA	Allentown
Idaho Department of Water Resources	ID	Boise
Idaho Power Company	ID	Boise
IDC	OR	Beaverton
Indiana Dept of Commerce - Energy Pol	IN	Indianapolis
Industrial Electric Co	WA	Everett
Industrial Electric Motor Service	ID	Twin Falls

Industrial Electric Motors	NE	Omaha
Industrial Electric Supply & Motor Rep	IL	Alton
Industrial Motor Rewinding Svc.	NC	Hickory
Industrial Power & Light	DC	Washington
Industrial Pump Sales & Service	RI	Tiverton
Ingleside Electric	GA	Macon
Iowa Association Of Municipal Utilitie	IA	Ankeny
Iowa Dept. of Natural Resources - Ener	IA	Des Moines
Iowa State University (EADC)	IA	Ames
IRS	TN	Memphis
ITOCHU International	MI	Madison Heights
J&R Consulting	OR	Portland
J K Kessler & Associates	FL	Tampa
J.L. Heinz & Associates	IL	Lombard
J T Katrakis & Associates	IL	Barrington
James A. Sewell & Associates	WA	Spokane
Jersco Engineering Corporation	CA	Corona
Jean Pullen	GA	Big Canoe
Jefferson - Smurfit	TX	Fort Worth
Jemco Electric Motor	ND	West Fargo
John Cerulli	NY	Clifton Park
Johnson & Johnson	NJ	New Brunswick
Johnston Pump Company	TX	Brookshire
Joliet Equipment Company	IL	Joliet
JSL Corp.	IL	Wheaton
K & H Sales	IN	Indianapolis
K C. Electric Association	CO	Hugo
Kaiser Cement Corporation	CA	Cupertino
Kaman Industrial Technologies	NY	Rochester
Kansas City Power & Light Company	MO	Kansas City
Keller Electric Motor Service	MN	Jackson
Kellogg - Memphis Plant	TN	Memphis
Kendal @ Hanover	NH	Hanover
Kenetech Energy Management	NY	Pearl River Plaza
Kentucky Division of Energy	KY	Frankfort
Kilpatrick & Carter	TX	Dallas
Kilpatrick & Carter	TX	Odessa
King Bearing	AZ	Casa Grande
King Bearing	AZ	Chandler
King Bearing	AZ	Chandler
King Bearing	AZ	Flagstaff
King Bearing	AZ	Morenci
King Bearing	AZ	Phoenix
King Bearing	AZ	Phoenix
King Bearing	AZ	Tucson

King Bearing	CA	Anaheim
King Bearing	CA	Antioch
King Bearing	CA	Bakersfield
King Bearing	CA	Burbank
King Bearing	CA	Clovis
King Bearing	CA	Colton
King Bearing	CA	Commerce
King Bearing	CA	Corona
King Bearing	CA	Eureka
King Bearing	CA	Fresno
King Bearing	CA	Gardena
King Bearing	CA	Gilroy
King Bearing	CA	Industry
King Bearing	CA	Long Beach
King Bearing	CA	Madera
King Bearing	CA	Merced
King Bearing	CA	Modesto
King Bearing	CA	Mountain View
King Bearing	CA	North Hollywood
King Bearing	CA	Oakland
King Bearing	CA	Ontario
King Bearing	CA	Pleasanton
King Bearing	CA	Ridgecrest
King Bearing	CA	Salinas
King Bearing	CA	San Diego
King Bearing	CA	San Jose
King Bearing	CA	Santa Ana
King Bearing	CA	Santa Fe Springs
King Bearing	CA	Santa Maria
King Bearing	CA	San Francisco
King Bearing	CA	South San Jose
King Bearing	CA	Stockton
King Bearing	CA	Suisun
King Bearing	CA	Tulare
King Bearing	CA	Turlock
King Bearing	CA	Ventura
King Bearing	CA	Victorville
King Bearing	CA	Watsonville
King Bearing	CA	West Sacramento
King Bearing	CA	Yuba City
King Bearing	IL	Batavia
King Bearing	IL	Burr Ridge
King Bearing	IL	Chicago
King Bearing	IL	Crestwood
King Bearing	IL	Elk Grove Village

King Bearing	IL	Elmhurst
King Bearing	IL	Peru
King Bearing	KS	Kansas City
King Bearing	NM	Bayard
King Bearing	NM	Farmington
King Bearing	NV	Sparks
King Bearing	TX	Austin
King Bearing	TX	Longview
King Bearing	TX	Lufkin
King Bearing	TX	Nederland
King Bearing	TX	Paris
King Bearing	TX	Rockdale
King Bearing	TX	Texarkana
King Bearing	TX	Texas City
King Bearing	TX	Tyler
King Bearing	TX	Waxahchie
Kirby Risk Electric Motor Repair	IN	Lafayette
Kirsner	GA	Marietta
Kluces Engineers Company	MN	Minneapolis
L&L Machinery Company	WA	Olympia
L.J. Anderson & Associates	MN	Rogers
Labor-Management Council for Economic	MI	Taylor
LaCrosse Footwear Inc	WI	LaCrosse
Lamour	OH	Dayton
Landis & Gyr Powers	IL	Buffalo Grove
Landsberg Engineering PC	NY	Fayetteville
Lange Electric Company	MD	Baltimore
Lano Oil & Gas Company	KS	Hays
Lawrence Berkeley Laboratory	CA	Berkeley
Lawrence Livermore National Lab	CA	Livermore
Learjet	KS	Wichita
Leeson Electric Corporation	WI	Grafton
Lehigh Portland Cement Company	PA	Allentown
Lemax	MD	Baltimore
Leonard & Associates - Baldor	IA	Des Moines
LG&E Power Engineers & Constructors	CA	Irvine
Liberty Technologies Inc.	PA	Conshohocken
Lincoln Electric Company	OH	Cleveland
Lincoln Electric System	NE	Lincoln
Little Rapids Corporation	NY	Potsdam
Lockheed Martin Astronautics	CO	Denver
Longo Industries	NJ	Morris Plains
Loral Infrared & Imaging Systems	MA	Lexington
Loren Cook Company	MO	Springfield
Los Angeles Times	CA	Los Angeles

Louis Allis Company	WI	Milwaukee
Louisiana Land and Exploration Company	LA	New Orleans
Louisiana Pacific Corp	ID	Harden
Loxcreen Inc	NC	Roxboro
LTV Steel Company	OH	Cleveland
Luck Stone Corporation	VA	Richmond
Macro International	MD	Calverton
Magna Force	WA	Port Angeles
MagneTek	TN	Nashville
Mainline Industrial Distributors - Gre	WI	Green Bay
Mainline Industrial Distributors - Mil	WI	Milwaukee
Management & Industrial Technology	TN	Signal Mountain
Manassas Electric Motor Company	VA	Manassas
Marathon Buildings Group	CA	San Francisco
Marathon Electric Manufacturing Corpor	WI	Wausau
Marion Electric Motors	FL	Ocala
Martin Marietta Armament Systems	VT	Burlington
Martin Sprocket	TX	Fort Worth
Massachusetts Division of Energy Resou	MA	Boston
McBroom Electric Company	IN	Indianapolis
McNichol Media Group	WI	Milwaukee
MECA Engineering	IL	East Chicago
Mellin Industries	FL	Oakland Park
Memorial Hospital @ Gulfport	MS	Gulfport
Memphis Light Gas & Water	TN	Memphis
Mercy Medical Center	WI	Oshkosh
Merion Pump Company	PA	Upper Darby
MET Engineers Inc.	MO	St. Louis
Metcalf & Eddy	CA	Palo Alto
Metropolitan Energy Center	MO	Kansas City
Michigan Public Service Commission	MI	Lansing
Micro Planet Ltd.	WA	Poulsbo
Middlebury Electric	IN	Goshen
Midland Electric Works	IL	Galesburg
Midwest Energy	KS	Hays
Midwest Power	IA	Des Moines
Mielke Electric Works Inc	MN	Duluth
Mikes Oil Field Service	OK	Lindsay
Minnesota Department of Public Service	MN	Saint Paul
Mirro Company	WI	Manitowoc
Missouri Division Of Energy	MO	Jefferson City
Missouri Farm Bureau	MO	Jefferson City
Missouri Valley Electric	MO	Kansas City
Mobil Oil Corporation - Hurricane	WV	Hurricane
Mohler Technology	IN	Boonville

Moldenhauer Engineering	CO	Longmont
Montenay Pacific Power Corporation	CA	Long Beach
Montgomery County Public Schools	MD	Rockville
Moorhead Public Service	MN	Moorhead
Morgan Products Ltd.	WI	Oshkosh
Motion Industries Inc. - HQ	AL	Birmingham
Motion Industries	AR	Little Rock
Motion Tech Trends	CA	Inglewood
Motor Technology	PA	York
Motor-Mation & Assoc.	IL	Rockford
Motortronics/Phasetronics Inc.	FL	Clearwater
Mountain Home AFB / 366 CES	ID	Mountain Home AFB
MS Consulting Engineers	MI	Southfield
MS Dept of Economic Development - Ene	MS	Jackson
Myriad Marketing Services	OK	Tulsa
Nalco Chemical Company	IL	Naperville
Narragansett Electric Co	RI	Providence
National Association of Manufacturers	DC	Washington
National Association of State Energy O	DC	Washington
National Center for Atmospheric Resear	CO	Boulder
National Electrical Manufacturers Asso	DC	Washington
National Lime Association	VA	Arlington
National Mining Association	DC	Washington
Navy Public Works Center - Virginia	VA	Norfolk
NCA Services	MI	Galesburg
Neshiem Electric Inc.	ND	Fargo
Nevada Power Company	NV	Las Vegas
Nevada State Energy Office	NV	Carson City
New England Power Service	MA	Westborough
New Horizons Enterprise	PR	San Juan
New Ideas	MO	Gladstone
Niagara Mohawk	NY	Syracuse
Noranda Aluminum Inc.	MO	New Madrid
North American Energy Services	NY	Lockport
North Carolina Energy Division	NC	Raleigh
North Coast Electric - Auburn	WA	Auburn
North Coast Electric - Tacoma WA	WA	Tacoma
North Texas Oil & Gas Association	TX	Wichita Falls
Northeastern Energy Concepts	VT	St. Johnsbury
Northern States Power Company - HQ	MN	Minneapolis
Northwest Center Industries	WA	Seattle
Northwest Center Industries	WA	Seattle
Northwestern Public Service	SD	Yankton
Notre Dame University (EADC)	IN	Notre Dame
Nova Scotia Power Inc	NS	Halifax
NRG Systems	CO	Boulder
NSWC Naval Sur Warfare Center	MD	Arnold
NSWC Naval Sur Warfare Center	MD	Arnold
O.A. Baumann Co. - Baldor	MO	Chesterfield
Ocala Electric Utility	FL	Ocala
Occidental Chemical	WA	Tacoma
Old Dominion University (EADC)	VA	Norfolk
Olson & Sons Electrical Inc	MN	Monticello
Operation Technology	CA	Irvine
Orange & Rockland Utilities	NY	Pearl River
Orange County Water District	CA	Fountain Valley
Oregon State University	OR	Corvallis
Oscar Meyer	TX	Sherman
Owatonna Public Utilities	MN	Owatonna
Pacific Gas & Electric Company - Chico	CA	Chico
Paco Pumps	CA	Commerce
Palmers Electric Motors	CT	Stamford
Peabody Holding Company	MO	St Louis
Pennsylvania Energy Office	PA	Harrisburg
Pennsylvania Hospital	PA	Philadelphia
Performance Technologies	CO	Evergreen
Peter Basso Associates	MI	Troy
Philadelphia Water Dept	PA	Philadelphia
Pinetree Power	NH	Bethlehem
Pittsburgh Intl Airport ARS - 911 Airc	PA	Corapolis
Planned Energy Management	MI	Canton
Plant Air Technology	NC	Charlotte
Platte River Power Authority	CO	Fort Collins
PM Realty Group	CA	San Francisco
PNM	NM	Albuquerque
Pocatello Regional Medical Center	ID	Pocatello
Polaroid Corp.	MA	Cambridge
Ponderosa Pulp Products	WI	Oshkosh
Pontiac Electric Motor Works	MI	Pontiac
Pope & Talbot	WI	Eau Claire
Portland Energy Conservation	OR	Portland
Power Conditioning Systems	NJ	Persippany
Power Service Shops (PSS)	AL	Muscle Shoals
Power Systems Associates	OH	Toledo
Power Technologies Inc	NY	Schenectady
Power Transmission Distributors Associ	IL	Rosemont
POWERTEC Industrial Corporation	SC	Rock Hill
PQES	CA	San Ramon
Pratt & Lambert	NY	Buffalo
Precision Devices	CT	Wallingford

Precision Electric	IN	Mishawaka
Prema	NE	Alliance
Pride Companies	TX	Abilene
Printpack	GA	Atlanta
Progressive Maintenance Technologies	MO	Lee's Summit
Public Service Company of Colorado - H	CO	Hayden
Public Service Company of Colorado - H	CO	Denver
Puget Sound Power & Light Company	WA	Bellevue
Pump Pro's	KY	Louisville
Quality Electric	KY	Louisville
Quinn & Associates Of CNY	NY	Auburn
Quintin Little Company	OK	Ardmore
R-M-S Professional Consultants	CA	Stockton
R F Wolters Co	GA	Norcross
R L Yates Electric Company	MO	North Kansas City
R S Boreham Co	AZ	Phoenix
R S Boreham Co	CA	Commerce
R W Rogers & Associates	NC	Greensboro
Raffi & Swanson	MA	Wilmington
Ragon Electric	OH	Canton
RAM Industries	PA	Reading
RC Cement Company	PA	Bethlehem
RCS Sales Company	NY	Westfield
Reading Municipal Light Department	MA	Reading
Reed Electric & Field Service	NV	Reno
Refractories Institute	PA	Pittsburg
ReHeis	TX	Midlothian
Reliance Electric - Bettendorf	IA	Bettendorf
Reliance Electric Company	OH	Cleveland
Resource Dynamics Corporation	VA	Vienna
Richmond Newspapers	VA	Mechanicsville
Rinehart Systems	IL	Northfield
River City Electronics Company	MI	Grandville
River Valley Electrical	AR	Menifee
Riverton Corporation	VA	Winchester
Rob-Lynns	SD	Box Elder
Robert Wood Johnson University Hospita	NJ	New Brunswick
Rogers Machinery Company	OR	Portland
Rossler Electric Motor	ID	Idaho Falls
Roulston Research	OH	Cleveland
RPL Energy Enterprises	NH	Manchester
Rural Electric Cooperative	OK	Lindsay
Rusch Electric Motor	WI	Waukesha
S.C. Electric & Gas Co	SC	Columbia
Saftronics	FL	Fort Myers
Sain Engineering Associates	AL	Birmingham
Salem Electric	OR	Salem
Sales & Engineering Associates	WA	Redmond
Sandman Electric	MA	Braintree
Santa Cruz Water Production	CA	Santa Cruz
Santa Ynez Valley Inn	CA	Buellton
Sarka Sales Inc - Baldor	GA	Tucker
Savage Engineering	CT	Bloomfield
Savo Electronics	OR	Covallis
SC State Energy Office	SC	Columbia
Schultz Electric Co	CT	New Haven
Scientific Protein Laboratories	WI	Waunakee
Seattle City Light	WA	Seattle
Sew-Eurodrive	SC	Lyman
Shambaugh & Son	IN	Fort Wayne
Shaw Industries	GA	Dalton
Shelby	CA	Los Angeles
Shorenstein Co	CA	San Francisco
Shour & Associates	MO	Kansas City
Showell Farms	FL	Defuniak Springs
Siemens Energy & Automation	OH	Norwood
Siemens Energy & Automation	KS	Overland Park
Sievert Electric Service & Sales Co	IL	Forest Park
Simkins Industries	CT	Newhaven
Skyline Services	IN	Indianapolis
Smith and Sun	CA	Berkeley
Snohomish County PUD	WA	Everett
Sol Engineering	CA	Ramona
Solar Turbines	DC	Washington
South Dakota State University (EADC)	SD	Brookings
Southeast Pump & Equipment	GA	Norcross
Southern California Edison Company	CA	San Dimas
Southern Electric Service Co	NC	Charlotte
Southwestern Public Service Co	TX	Amarillo
Southwestern Technical College	MN	Jackson
Spencer Turbine Company	CT	Windsor
Spina Electric Company	MI	Warren
Springfield Utility Board	OR	Springfield
Square D	SC	Seneca
SSI	CA	San Jose
St. Francis Medical Center	WI	LeCrosse
St. Joseph Church & School	KY	Bowling Green
Stefanovic Consulting	VA	Afton
Sterling Electric	CA	Irvine
Stocker Resources	CA	Los Angeles

Stone & Webster Energy Services	NJ	Cherry Hill
Strategic Planning for Energy and the	GA	Marble Hill
Sub-Zero Freezer Company	WI	Madison
Superior Carbon Products	MS	Walnut Grove
Sycom Enterprises	NJ	South Plainfield
Synchrotek	WI	Appleton
System Planning Corporation	VA	Arlington
Tacoma Public Utilities	WA	Tacoma
Tate Electric	MO	Chillicothe
Teco American	TX	Houston
Tecsyn PMP Inc.	AL	Huntsville
Tellus Institute	MA	Boston
Tennessee Technology Center	TN	Pulaski
TENSA	TX	Houston
Texas A&M University (IAC)	TX	College Station
TKL Enterprises	TX	Brazonia
Toshiba International Corporation - De	CO	Denver
Toshiba International Corporation - Ho	TX	Houston
Tower Sales Company	NJ	Princeton
Town of Trumbull	CT	Trumbull
Transmission Equipment Co. Inc.	CT	Wallingford
Tri-County Electric Cooperative	MN	Rushford
Tucson Electrical Power	AZ	Tucson
TXI	TX	Midlothian
Tyler Refrigeration	TX	Waxahachie
U S Army Garrison	AR	Fort Chaffee
U.S. Industrial Sales	WI	Milwaukee
U.S. Mint - Philadelphia	PA	Philadelphia
U.S. Mint - Washington	DC	Washington
U.S. Postal Service - MTSC	OK	Norman
U.S. Products Inc. (Motor Division)	ID	Hayden
United Electric Motors	PA	Washington
United Illuminating	CT	New Haven
University of Alabama in Huntsville	AL	Huntsville
University of Arkansas (EADC)	AR	Little Rock
University of California at San Diego	CA	La Jolla
University of Colorado at Denver	CO	Denver
University of Kansas	KS	Lawrence
University of Nevada @ Reno	NV	Reno
University of Southern Colorado Energy	CO	Pueblo
University of Wyoming (WEMTTC)	WY	Laramie
US Army	AZ	Fort Huachuca
US Electrical Motors	MO	St Louis
Utility Focus	TN	Brentwood
VA Medical Center	VT	White River Junctio
Vallejo Electric Motor Shop Inc.	CA	Vallejo
Victor Ferrante	VA	Arlington
Virginia Power	VA	Richmond
Visual Computing Systems Corp.	IN	Greenville
Volland Electric Equipment Company	NY	Buffalo
Wagner Electric Of RTW	IN	Fort Wayne
Walco Electric Company	RI	Providence
Warner-Lambert	NJ	Morris Plains
Washington State Energy Office	WA	Olympia
Washington Water Power Co	WA	Spokane
Waupaca Foundry	WI	Waupaca
Wausau Electric	WI	Weusau
Wayne Memorial Hospital	NC	Goldsboro
Wazee Electric Company	CO	Denver
Weldy-Lamont Associates	IN	Munster
West Texas Utilities	TX	Abilene
West Virginia Development Office	WV	Charleston
Westburgh Electric	NY	Jamestown
Western Fuels Association	DC	Washington
Westinghouse - Kansas City MO	MO	Kansas City
Westinghouse EMD - Export	PA	Export
Westmoreland Coal Company	PA	Philadelphia
Westvaco Corporation	KY	Wickliffe
Weyerhaeuser	WA	Tacoma
WG International Group	MD	Rockville
William R. Putman & Associates - Baldo	CA	Hayward
Williamson-Dickie Manufacturing Co	TX	Fort Worth
Wisconsin Center for Demand-Side	WI	Madison
Wisconsin Demand-Side Demonstrations	WI	Madison
Wisconsin Energy Bureau	WI	Madison
Wolthers Motor & Drives	GA	Norcross
Wulfinghoff Energy Services	MD	Wheaton
Xenergy Inc. - HQ	MA	Burlington
Xenergy	CA	Oakland
Yeomans Chicago Pump Company	IL	Melrose Park
Youth Center at Beloit	KS	Beloit
Zeks Air Drier Corporation	PA	Malvern

Attachment 350 (b):

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COMPANY	STATE	CITY
AIR Engineering and Testing, Inc.	TX	Dallas
Alfred Greenberg Associates	NJ	Murray Hill
Alvord, Burdick & Howson	IL	Chicago
American Cyanamid Company	NJ	Princeton
American Home Foods	PA	Milton
Amoco Fabrics and Fibers	NC	Rocky Mount
Applied Materials	CA	Santa Clara
Arkansas Energy Office	AR	Little Rock
Armstrong World Industries, Inc.	PA	Lancaster
Ash Grove Cement Company	KS	Chanute
Associated Consultants Engineers, Inc.	MN	Minneapolis
AstralTech Americas, Inc.	FL	Boca Raton
AT&T Global Information Solutions	UT	Ogden
Aura Systems	CA	El Segundo
Ayerst-Wyeth Pharmaceuticals, Inc.	PR	Guayama
Baltimore Gas & Electric Company	MD	Baltimore
Bay Armature & Supply Company	FL	Tampa
Bay Motor Winding	MS	Long Beach
BBF & Associates	MA	Weston
Bechtel Corporation	CA	San Francisco
Beehive Clothing Mills	UT	Salt Lake City
Berkeley Applied Science & Engineering, Inc.	CA	San Francisco
Bestway Electric Motor Service Co., Inc.	AZ	Tuscon
BJLJ Engineers & Architects, P.C.	NY	Mineola
Bridgestone/Firestone Inc. - Wilson Plant	NC	Wilson
Brogan Medical International, Inc.	ID	Boise
Burlington Industries, BH Finishing	NC	Burlington
Burlington Industries, BHAR I	AR	Monticello
Burlington Industries, BM Combing	VA	Clarksville
Burlington Industries, BM Dyeing	NC	Raeford
Burlington Industries, Clarksville Finishing	VA	Clarksville
Burlington Industries, Denton	NC	Denton
Burlington Industries, Glasgow	VA	Glasgow
Burlington Industries, Halifax	VA	Halifax
Burlington Industries, Hurt Finishing	VA	Hurt
Burlington Industries, Inc.	NC	Greensboro
Burlington Industries, Johnson City	TN	Johnson City
Burlington Industries, Mayodan	NC	Mayodan
Burlington Industries, Mooresville	NC	Mooresville
Burlington Industries, Oxford	NC	Oxford
Burlington Industries, Pine Tree	GA	Dahlonega
Burlington Industries, Richmond	NC	Cordova
Burlington Industries, Robeson	NC	St. Pauls
Burlington Industries, Sheffield	NC	Rocky Mount
Burlington Industries, Smithfield	NC	Smithfield
Burlington Industries, St. Pauls	NC	St. Pauls
Burlington Industries, Stonewall	MS	Stonewall
Burlington Industries, Wake Finishing	NC	Wake Forest
Burlington Industries, Williamsburg	NC	Burlington
Burlington Public Works	VT	Burlington

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COMPANY	STATE	CITY
C J. Schneider Engineering Company	NE	Omaha
Carpenter Company	CA	Riverside
Cella Barr Association	AZ	Tucson
Central Hudson Enterprises Corporation	NY	Poughkeepsie
Ceradyne Thermo Materials	GA	Scottsdale
Chemical Processing	IN	Fort Wayne
Cimarron Electric Cooperative	OK	Kingfisher
Circuit Technologies Inc.	GA	Doraville
City of Palo Alto Utilities	CA	Palo Alto
Coast Energy Management, Inc.	AZ	Tempe
Colonial Williamsburg Foundation	VA	Williamsburg
Computational Systems, Inc.	TN	Knoxville
ConservAIR Technologies Company	WI	Kenosha
Conservation Management Corp.	MD	Bethesda
Continental General Tire	IL	Mt. Vernon
Control Assemblies Company	MN	Minneapolis
Copper Development Association Inc.	NY	New York
Cowherd Electric Motors, Inc.	VA	Arlington
Dakota Growers Pasta Company	ND	Carrington
Dennison Electric	OH	Cleveland
Department of Corrections, State of Florida	FL	Orlando
Dept. of Business, Economic Dev., & Tourism	HI	Honolulu
Duluth Steam Co-op	MN	Duluth
E Source, Inc.	CO	Boulder
East Central Electric Association	MN	Braham

COMPANY	STATE	CITY
East Kentucky Power Cooperative	KY	Winchester
Eastern Illinois University	IL	Charleston
Easton Consultants, Inc.	CT	Stamford
Eaton Corporation	WI	Milwaukee
Edwin L. Heim Company	PA	Harrisburg
Electric Motor Service of Ahoskie Inc.	NC	Ahoskie
Electrical Equipment Company	VA	Richmond
Electro Standards Labaratory	RI	Cranston
Elektran, Inc	NC	Rockingham
EMC Technologies, Inc.	OK	Tulsa
Energy and Environmental Services	SC	Georgetown
Energy Auditors & Consultants, Inc.	MA	Amherst
Energy Conservation Corp	MI	Troy
Energy Leadership Services	IN	Valparaiso
Energy Simulation Specialists, Inc.	AZ	Tempe
Energy Systems Engineering, Inc.	MD	Kensington
Enviro Systems Company	CA	Atwater
Environmental Systems Design	IL	Chicago
Essex Group - Franklin, IN	IN	Franklin
Essex Group - Franklin, TN	TN	Franklin
Essex Group - Ft. Wayne, IN	IN	Fort Wayne
Essex Group - Kendalville, IN	IN	Kendallville
Essex Group - Rockford, IL	IL	Rockford
Essex Group - Vincennes, IN	IN	Vincennes
Essex Group, Inc., MWI Sector	IN	Fort Wayne

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COMPANY	STATE	CITY
Essex Group, MaCallen	NH	Newmarket
Essex Group, Suflex	NH	Newmarket
Essex Group, US Samica	VT	Rutland
Essex Group/Essex Express	NC	Charlotte
etc Group, Inc.	UT	Salt Lake City
Eurand America Inc.	OH	Vandalia
Eveready Battery Company	MO	Maryville
Exide Electronics	NC	Raleigh
Expense Audit & Consulting Company, Inc.	PA	Reading
Final Design, Inc.	MI	Royal Oak
Fred Arms Electric Motor Repair & Sales	IL	Stone Park
Freeport Electric	NY	Freeport
G E Jones Electric Company Inc.	TX	Amarillo
GDS Engineering, Inc.	TX	Baytown
GE - Supply	IN	Griffith
Georgia Power Company (1)	GA	Atlanta
Georgia Power Company (2)	GA	Atlanta
Gillan & Hartmann, Inc.	PA	Valley Forge
Goldmark Engineering Inc	WY	Casper
Goodhue County Cooperative Electric	MN	Zumbrota
Grand River Dam Authority	OK	Schouteau
Grant-Lafayette Electric Co-op	WI	Lancaster
GRASP	PA	Philadelphia
Greg's Electric Motor Service	KS	Ransom
Gulf Western Electric, Inc	LA	Baton Rouge
Hawaii Electric Light Company	HI	Hilo
Hawaiian Electric Company	HI	Honolulu
Hazen and Sawyer, P.C	NY	New York
HEC, Inc.	MA	Natick
Honeywell Home & Building Controls	NJ	Marlton
Honeywell, Inc.	MI	Farmington Hills
Hot Springs REA, Inc.	WY	Thermopolis
Houston Armature Works - Baton Rouge, LA	LA	Baton Rouge
Hunter Electric Motor & Supply Inc.	GA	Columbus
Hydro-Tech International	GA	Marietta
ICI Films	VA	Hopewell
Industrial Belting & Supply	MI	Grand Rapids
Industrial Electrical Company	CA	Modesto
Industrial Engineering Equipment Company	IA	Davenport
Inland Steel Company	IL	Chicago
International Institute for Energy Conservation	DC	Washington
Irving Materials Inc.	IN	Anderson
J. Rossi Engineering	OH	Pickerington
Jafra Cosmetics International	CA	Westlake Village
JBAR & Associates, Inc.	TX	Houston
Jenkins Electric Company, Inc.	NC	Charlotte
Johnson Controls, Inc. (1)	VT	Colchester
Johnson Controls, Inc. (2)	NY	Long Island City
Kirkwood Meadows Public Utility District	CA	Kirkwood
Larry Wunsch & Associates, Inc.	TX	San Antonio

Motor Challenge Partners - FY 1996

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COMPANY	STATE	CITY
Leisure Management International	AL	Brownsboro
Lincoln Electric	MO	St. Louis
Lockheed Martin Energy Systems, Y-12 Plant	TN	Oak Ridge
Lower Colorado River Authority	TX	Austin
Lubbock Electric Company	TX	Lubbock
Magnatek-National Electric Coil	PA	Pittsburgh
Malcolm Pirnie	NY	White Plains
Mason & Hanger-Silas Mason Co. Inc.	IA	Middletown
McGladrey & Pullen	IL	Schaumburg
Meade Industrial Services Inc.	IN	Hammond
Mechanisys	OH	Cincinnati
Medina Electric Cooperative, Inc.	TX	Hondo
Miceli Energy Engineering	GA	Marietta
Michelin Tire Corp.	SC	Greenville
Milbank Systems, Inc.	MO	Kansas City
Mobile	TX	Convoe
Naknek Electric Association, Inc.	AK	Naknek
National Electric Motor & Supply Company	LA	Baton Rouge
National Power Systems (1)	FL	Miami
National Power Systems (2)	OK	Tulsa
New England Electric	MA	Westboro
New York Power Authority	NY	New York
New York State Electric & Gas Corporation	NY	Binghampton
New York State Energy R&D Authority	NY	Albany
Noah's Bagels	CA	San Leandro
Noyes Air Conditioning Contractors, Inc	MD	Gaithersburg
Onsite Energy Corporation	CA	Carlsbad
ORE-IDA Foods Inc.	ID	Boise
Otter Tail Power	MN	Fergus Falls
Pacific Power	OR	Medford
Penn Ventilator Company Inc.	PA	Philadelphia
Phillips Electric	OH	Cleveland
Piedmont EMC	NC	Hillsborough
PMW Consultants	CA	Palo Alto
Portland General Electric	OR	Portland
Potlach Corporation, Wood Products	ID	Lewiston
Potomac Energy Group	VA	Alexandria
Power Partners	GA	Atlanta
Purdue University	IN	West Lafayette
R.C. Lambert & Associates, Inc.	MN	Roseville
Ralph Hahn & Associates, Inc.	FL	Orlando
Ralston Purina Company	IA	Davenport
RAM-TECH Engineers, P.C.	NY	Syracuse
Renewable Energy Technology	PR	Sabana Grande
Research & Training Resources	VA	Reston
Resource Management Association	WI	Madison
Reuland Electric Company	OH	Cincinnati
RI^2 Energy Management Services	NC	Mebane
Roche Vitamins & Fine Chemicals	NJ	Belvidere
Rochester Gas & Electric	NY	Rochester

Motor Challenge Partners - FY 1996

as of 4/24/96

COMPANY	STATE	CITY
Rock Island Electric Motor Repair, Inc	IL	Rock Island
Roth Brothers Smelting Corporation	NY	East Syracuse
Rountree & Associates, Inc.	OR	Oregon City
Salas O'Brien Engineers, Inc.	CA	San Jose
Schunicht Engineering	TX	Houston
SDSU Industrial Assessment Center	CA	San Diego
Shoemaker Electric Company	OH	Columbus
Solutions Engineering & Facilitating, Inc	CO	Littleton
Source Translation & Optimization	MA	Belmont
Southern Design Consultants, Inc.	FL	Oviedo
Southern Minnesota Municipal Power Agency	MN	Rochester
Southwestern Petroleum Corporation	TX	Fort Worth
Stanco Power Systems, Inc	NJ	Emerson
State of Washington, Military Dept. - East	WA	Fairchild AFB
Swiss Miss Foods	WI	Menomonie
System One Solutions, Inc	FL	Jacksonville
T & C Design	FL	Lakeland
T Gray Electric Company Inc.	TX	Dallas
Technical Service Group	NY	Napanoch
Tennessee Armature & Electric	TN	Knoxville
Texas Energy Engineering Services, Inc.	TX	Austin
Total Petroleum Refinery	CO	Commerce City
Tredegar Film Products	IA	Manchester
U.S Bearings & Drives - Missoula, MT	MT	Missoula
U S Bearings & Drives - Portland, OR	OR	Portland
U.S Mint - Denver, CO	CO	Denver
U.S. Silica Company	SC	West Columbia
UGIMAG, Inc.	IN	Valparaiso
Umatilla Electric Cooperative	OR	Hermiston
Union Electric	MO	St Louis
Univ. of Arizona, Facilities Mgmt., Engineering	AZ	Tucson
University of Iowa	IA	Iowa City
Utah Office of Energy Services	UT	Salt Lake City
Utility Analysts, Inc.	MS	Jackson
Vaughn Electric Company, Inc.	TN	Union City
Veterans Affairs Palo Alto Health Care System	CA	Palo Alto
Voinovich Group	OH	Cleveland
W.S. Nelson & Company, Inc	LA	New Orleans
Weldy/Lamont Associates, Inc - Mt. Prospect,	IL	Mt Prospect
Wesco Technologies	NY	New York
Wheat Belt Public Power District	NE	Sidney
White Stone Company	VA	Castlewood
Woodland Generation Station	CA	Modesto
Wyeth-Ayerst Laboratories	PA	Marietta
Xenergy, Inc. (Michigan)	MI	Whitmore Lake
Zeller Electric	MO	St. Louis
Zimco Electric	TX	Odessa

Q351. Please provide a listing of the recipients of (i) the $5,153,000 in funding in FY 1995, (ii) the $5,205,000 in FY 1996 funding, and (iii) the requested level of $7,350,000 in FY 1997 for Motor Challenge.

A351. Funding recipients for FY 1995, FY 1996 and FY 1997 are shown below (x denotes received funding, ------ denotes did not receive funding).

		Received Funds		
No.	**Major Recipient**	**FY 1995**	**FY 1996**	**FY 1997**
1	National Renewable Energy Laboratory	x	x	x
2	Oak Ridge National Laboratory	x	x	x
3	Lawrence Berkeley National Laboratory	x	x	x
4	Macro International	x	x	x
5	Washington State Energy Office	x	x	x
6	Xenergy	x	x	x
7	Resource Dynamics Corporation	x	x	x
8	Flowcare Engineering	x	------	------
9	SAIC	x	------	------
10	Easton Consultants	x	------	------
11	Electrical Apparatus Service Association	x	x	x
12	Consortium for Energy Efficiency	x	------	------
13	Hydraulic Institute	x	x	x
14	Wisconsin Energy Center	x	------	------
15	Kansas Electric Utility Research Program	x	------	------
16	Bonneville Power Administration	------	x	x
17	American Council for an Energy Efficient Economy	------	x	x
18	Flowcare Engineering	------	x	x
19	Environmental Plus	------	x	
20	Compressed Air and Gas Institute	------	------	x

Q352. For each recipient of Motor Challenge funds identified in the response to question 351 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A352. Motor Challenge resources, products, and technical assistance are delivered broadly to the 1,300 plus industry partners. Motor Challenge funding recipients are National Labs, contractors or trade associations that are responsible for developing and delivering products and services that are beneficial to all of the Motor Challenge partners.

Direct cost share relates primarily to the Showcase Demonstrations where the 33 Showcase Demonstration teams are collectively investing approximately $15 million compared to Motor Challenge's $1.5 million per year in technical assistance to the teams. Again, Showcase Demonstration teams receive no direct financial assistance from DOE.

Other cost-sharing is indirect and can be measured in terms of the thousands of industry people participating and being involved in the Program. Examples of industry's investment of time and resources include:

- Attendance at meetings, conferences. and workshops (see question 350 answer).
- Trade magazines running public service announcements about the Motor Challenge.
- Participation in Allied Partner events and dissemination of Motor Challenge products.
- Participation in the Excellence Partner program and sharing of best practices.
- Trade association activity in developing new industry equipment specification guidelines and related tools and products, and to review new Motor Challenge products.
- Industry participation in Motor Challenge training events.
- Clearinghouse users.

Q353. For those Motor Challenge funding recipients identified in the response to question 351 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A353. **Electrical Apparatus Service Association (EASA):** EASA is an international trade association of more than 2,500 mostly small- to medium-sized member companies involved with the sale and service of industrial electric motors, adjustable speed drives, and other electro-mechanical equipment. The DOE cooperative agreement with the Electrical Apparatus Service Association will develop a number of informational and educational materials aimed at assisting end-users to maintain electric motor efficiency during repair and rewind. EASA is providing the technical oversight and management support for the project at no cost. EASA is unique in that they represent the majority of motor repair shops in the U.S. and were the only organization capable of seeking the type of industry guidance needed to complete the work.

Hydraulic Institute (HI): The Hydraulic Institute (HI) is considered the authority on pumps, pumping systems, and pumping technology. The Institute is involved in the development of standards, providing engineering/technical conferences, sponsorship of cooperative research, and other type of cooperative projects with engineering and technical organizations. HI staff have substantial experience in developing technical information on pumps and pumping systems and has worked on several similar projects internally and with other organizations. The agreement with HI leverages their substantial expertise with pumping technology and their experience with development of technical education materials that could not be found in any other national organization.

Energy Center of Wisconsin (ECW):

Midwest Motor Systems Collaborative (MMSC) Project. In 1993 DOE Motor Challenge sought to initiate efforts to facilitate stakeholder collaboration and develop information and data related to industrial electric motor systems in a ten- State area in the industrial Midwest (Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, Wisconsin). The project aimed to interact with, and gather input and stakeholders on market and technical barriers in implementing efficient electric motor systems. ECW is the only known Midwest non-profit organization that has a motor systems initiative and for that reason were selected to assist in coordinating the MMSC.

Performance Optimization. In 1994, the Motor Challenge program developed an agreement with the ECW to develop activities around Performance Optimization (optimization of motor-driven pump, fan and blower systems). ECW developed a Performance Optimization Program that focused on field assessment methods used to identify and evaluate efficiency opportunities in industrial motor-driven fan, pump, and blower systems. ECW developed core training materials and workshop curricula, and conducted both marketing and technical Performance Optimization workshops. The noncompetitive cooperative agreement between the Motor Challenge Program and ECW leveraged a substantial ECW investment in material and training development, and organizational expertise in the performance optimization approach.

Kansas Electric Utility Research Program: KEURP and its member utilities, along with the Kansas Corporation Commission, and the Department of Energy Kansas City Regional Support Office supported a motor system efficiency project related to oil pumping applications--a primary Kansas industry. As a result of this effort DOE and KEURP saw the need for training and technical assistance on the correct and efficient application of adjustable speed drives in new and retrofit industrial processes. KEURP agreed to contribute management support to facilitate training and technical assistance on the correct and efficient application of adjustable speed drives (ASDs) in new and retrofit industrial processes, and to cooperate with DOE and other organizations in developing new information or decision making tools that will assist in ASD applications.

Easton Consultants: Easton Consultants has substantial experience in carrying out market and technology assessment studies related specifically to electric motor systems. Easton has conducted several studies of this nature with support of Canadian and U.S. utilities, government agencies, and equipment manufacturers. Those efforts included the "New England Motor Baseline Study," "Commercial Refrigeration Baseline Study," and "HVAC Baseline Study."

In addition to the above referenced experience, DOE/OIT participated in the "Original Equipment Manufacturers (OEM) Study" conducted by Easton. That study developed information which characterized the equipment markets and described industry practices which impact upon the equipment and the system level efficiency. Easton also had earlier performed a study called "Strategies to Promote Energy Efficient Motor Systems in North America's OEM Markets" that DOE cost-shared with other organizations. DOE's activities with Easton takes benefit of work that has not been performed by any other organization, which makes Easton a unique provider.

Washington State Energy Office: The Washington State Energy Office is in a unique position to provide Motor Challenge Information Clearinghouse services, since they operate the successful Electric Ideas Clearinghouse that provides technical information on energy efficiency in commercial and industrial sectors. Because the Clearinghouse has the infrastructure in place, the Motor Challenge hotline can be serviced by WSEO Clearinghouse staff at a lower cost by leveraging the program dollars with other sponsors.

Another function of the Motor Challenge Clearinghouse is to distribute the Motor Master Software package which was developed by the Washington State Energy Office. This software is not available from any other organization. The Motor Challenge Information Clearinghouse benefits from the WSEO expertise that created the Motor Master software, and the product information, and manufacturer contacts used to develop the updated versions.

CEE: The Consortium for Energy Efficiency is a consortium of electric utilities that collaborate to promote and deploy energy efficient technologies. CEE is the only utility-based organization that has as its mission to promote energy efficiency. Accordingly, Motor Challenge provided funding to support the CEE Motor System Committee to work on the development of new utility motor system initiatives in the new era of utility deregulation.

SAIC: The statement of work called for a contractor to develop software to be added to MotorMaster Plus that would summarize energy savings achieved in motor systems and provide the capability to report the savings to DOE. It was necessary that this reporting be accomplished in a manner that was compatible with the EPAct section 1605b voluntary greenhouse gas emission reporting system and database so that Motor Challenge savings could be aggregated and sent directly to the 1605b database. SAIC was chosen by the Energy Information Administration (EIA) as the contractor to develop the 1605b database. Thus, Motor Challenge selected SAIC to maintain consistency with 1605b.

Flowcare Engineering: As part of the Independent Performance Validation work for the Motor Challenge Showcase Demonstrations, a general technical consultant was required in the area of system performance optimization, electric motors, variable speed drives, pumps, fans, blowers, and compressors. Flowcare Engineering was selected because of their unique history in performing the type of work specifically called for in the IPV and their intimate knowledge of the Motor Challenge Program. Because of their systems background, the expertise in documenting motor system efficiency projects, and their expertise in the systems and components of interest there was no other contractor that could meet the schedule, perform the work within budget, and perform at a level of competency required by DOE.

Resource Dynamics Corporation: Program support was required including: preparation of Showcase Demonstration case study preparation, coordination and management of national team meetings, and development and coordination of communication forums among Showcase teams. The contractor must have a strong electric motor systems background, capabilities in communication and coordination among diverse groups, and have an established working relationship with the Motor Challenge Partners who become Showcases. An intimate working knowledge of Motor Challenge was also required in order to define the support requirements. RDC possessed this background and capabilities and was, therefore, chosen as the contractor for this work in order to meet schedule and budget requirements.

Environmental Plus: A Cooperative Agreement between Environmental Plus and the DOE is being awarded to fund a series of financing workshops for industrial manufacturers. The proposal addresses opportunities for manufacturers to leverage funding by bringing together a multitude of public/private sector resources directed at helping industry accomplish efficiency and environmental goals. The workshops envisioned in the proposal will be of special benefit to small- and mid-sized manufacturers. Environmental Plus has developed a group of collective resources and expertise in the area of energy efficiency capital financing. Additionally, high leverage and cooperation will be sought in the financial community, insurance industry, utilities, and energy service companies (ESCO's). The proposal builds on numerous financing projects in which Environmental Plus has participated in.

Q354. On page 510 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated in the FY 1995 column for Motor Challenge: "The benefits of the Motor Challenge relate to energy efficiency, improved manufacturing productivity, and environmental improvement. The 25 billion kW-hr/year of electricity savings translates to $1.25 billion in cost savings and 6 million metric tons of carbon equivalent (MMCTE) of emissions reduction per year."

Q354a. Please provide detailed documentation of these claims, including the peer review process undertaken.

A354a. The initial estimation of Motor Challenge program metrics and benefits were prepared in early FY 1996. The results of these estimates showed an overall energy savings of 25 billion kilowatt-hours per year by 2000. These early estimates were largely based on projections of energy-efficient product market penetration (number of new efficient motor systems that penetrate the market) as compared to the more recent metrics that have been developed which quantify the extent to which Motor Challenge partnerships achieve energy savings at the plant site level–Showcase Demonstrations, Excellence Partner plant sites, and Allied Partner assistance to plant sites. After the initial estimates were prepared, DOE secured independent peer review from Arthur D. Little Consultants and Decision Analysis Corp. The independent peer review made several suggestions of how to improve the analysis. Subsequently. DOE reevaluated the program's metrics and derived the lower 12.5 billion kWh/year energy savings projected and described in question 319a. Therefore, the energy savings claimed in the FY 1997 budget (page 510) were erroneously not revised to reflect the new estimates (quoted on page 503 of the FY 1997 budget).

Q354b. Please document why these benefits would not occur in the absence of DOE funding.

A354b. The basis of the revised Motor Challenge benefits, metrics and energy savings claimed were described in question 349a (12.5 billion kilowatt-hours per year). Similarly, the reasons of why these benefits would not occur in the absence of the DOE Motor Challenge program, and the funding the Program provides are the same reasons as answered to question 349b. To repeat and summarize, DOE's unique role is in facilitating a national industry/government partnership which provides unbiased, reliable and validated information, tools and products. DOE has no vested interest and supports activities that empower and catalyze industrial end users to demand energy-efficient motor systems in a more accelerated and expanded manner. Correspondingly, this end-user market pull will encourage the market to supply the products and services that enables the energy efficiency actions to be captured, more extensively and cost-effectively.

Q355. Page 503 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the National Industrial Competitiveness through Energy, Environment, and Economics (NICE-3) Program:

	2000	2010	2020
Energy Savings (quads)	**.267**	**.596**	**.67**
Energy Cost Savings ($billions)	**1.92**	**5.47**	**6.53**
Carbon Savings (MMTCE)	**5.788**	**12.129**	**13.252**

Q355a. Please provide detailed documentation of each of these claimed benefits.

A355a. **Summary:** Program benefits for the NICE-3 Program are derived from an analysis of each of the projects that have received funding through FY 95. The benefit of each individual project is summed and averaged to create a model project that represents the portfolio average. Future benefits are based upon actual projects already in place and projections of benefits derived from the deployment of new "portfolio average" projects. Market size and penetration rates are estimated to model the replication of these projects. A detailed description of the methodology follows:

QM Sector Analysis: OIT conducts detailed, project-level analysis of the energy, economic, and environmental characteristics for each of the technology research and development projects it funds. Analysis is performed using a computer-based modeling tool called the OIT Project Benefit Analysis Worksheet that was developed specifically for this purpose. The modeling tool enables OIT to compare the predicted technical and market performance of new, energy-efficient technologies with the current state-of-the-art technology alternative by assessing their relative costs, energy use (by fuel type), waste reduction, and market performance. The model employs standard financial evaluation methodologies to compare alternate technology investments over the lifetime of the technology, including the internal rate of return for a technology investment.

Data required to compete technology investments is obtained from research performers, equipment users, industrial studies, government-collected data, and manufacturers. These data are reviewed by several DOE experts in the appropriate technology area to verify that the information is accurate and sound. The model calculates a project's expected energy and cost savings based on the fuels displaced/used (by type), fuel-specific energy costs, relative capital and operating costs, non-fuel production cost savings, equipment life, size of the market, the market penetration rate, and other project specific information. Energy costs savings are calculated based on the type and amount of fuel saved and the cost of that fuel for the industrial sector. Fuel costs are based on national surveys of fuel expenditures for each State as reported by the Energy Information Administration. Environmental benefits include the reduction in combustion-related emissions that are avoided by employing the more energy-efficient technology. They are calculated using the amount of fuel combustion avoided and their associated emissions loadings (SO_2, NO_x, CO_2, etc.). Energy, cost, and environmental benefits reported for a specific program represent the aggregated benefits of the individual projects included within that program. The 41 projects in NICE-3 have been analyzed using this model.

QM Integrated Results: In addition to the rigorous sector analysis conducted, the Quality Metrics process used an integrated model to perform an equilibrium analysis to estimate sector totals. By using an integrated model interactions between programs within a sector can be accounted for (for example, efficiency programs reducing electricity demand) and double counting can be eliminated.

Quality Metrics peer review: EERE contracted with Arthur D. Little (ADL) to design and implement an external peer review process of these estimates. ADL examines technology assumptions and resulting market penetration of EERE technologies. Most of the high impact and high uncertainty programs have been reviewed, and ADL is currently completing the review of the remaining technologies. ADL's external review of metrics and results for NICE-3 is currently underway.

BENEFITS BY NICE-3 PROJECT

NICE-3 Project	Energy Savings (Quads)			Energy Cost Savings ($ Billion)			Carbon Savings (MMTCE)		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
40% Recycled Paper	.007	.032	.038	.018	.082	.098	.14	.61	.73
Advanced Mineral Calciner for Lime Regeneration	.001	.007	.017	.001	.019	.049	.008	.095	.239
Alternative Aircraft De-icing Method	0	.035	.100	0	.045	.126	.003	.561	1.58
Aluminum Recycling: Automobile Wheels Mfr.	0	.001	0	.001	.002	.001	.006	.012	.006
Atmospheric Recovery and Regeneration in Heat Treating	0	.003	.049	0	.007	.143	.002	.038	.69
Automated Dye Reuse in Carpet Manufacture	.006	.008	.002	.023	.028	.007	.098	.122	.033
Bioconversion of Low Value Molasses to Phytochelates	.001	.005	.002	.0	0	0	.017	.168	.067
Brine Reuse Project	0	.001	.001	.0	0	0	.002	.017	.021
Closed Cycle Kraft Pulp	.006	.045	.053	.191	.134	.158	.091	.634	.747
Cullet Feedstock Purification using Fiber Optical Sortation	.003	.007	.007	.014	.020	.032	.057	.112	.124
Dense Fluid Extraction Product Cleaning	0	.001	.005	0	.003	.014	.002	.018	.066
Direct Copper Plating	0	.002	.003	0	.003	.003	.009	.058	.07
Direct Osmosis Concentration of Tomato Paste	0	0	.001	0	.001	.001	.001	.006	.009
Electric Tundish for Copper Bar Manufacture	0	0	0	0	0	0	.006	.006	.005
Electrophotographic Screening for Color TV Manufacture	.001	.002	.001	.003	.009	.003	.014	.033	.014
Finishing Using Cathodic Arc Deposition	0	0	0	0	0	0	0	0	.003
Fuel Based Nitrogen Generator	0	.005	.013	.001	.023	.057	.004	.088	.211

NICE-3 Project	**Energy Savings (Quads)**			**Energy Cost Savings ($ Billion)**			**Carbon Savings (MMTCE)**		
	2000	**2010**	**2020**	**2000**	**2010**	**2020**	**2000**	**2010**	**2020**
Full Body Powder Antichip Coatings-Automobiles	.001	.001	0	.002	.003	0	.011	.014	0
HCL Acid Recovery System	.001	.003	.004	.004	.008	.010	.032	.069	.082
Ink Jet Supply and Printer Solvent Recovery	.012	.014	.003	.052	.064	.014	.195	.238	.055
Innovative Blanching Technology	.001	.023	.030	.003	.078	.104	.016	.374	.495
Innovative Brick Kiln Design for Agile Manufacturing	.020	.052	.059	.061	.160	.180	.283	.737	.831
Manufacture of Tissue Paper with High Content PCW	.003	.032	.039	.004	.060	.075	.052	.65	.809
Membrane Filtration Technology	0	0	.003	0	.003	.032	0	.001	.006
Methanol Recovery	0	0	0	0	0	0	.002	.002	0
Nickel Plating Solutions	0	.001	.001	0	.003	.004	.001	.015	.018
Pallet Manufacturing Using Thermoplastic/Cellulose Composites	.029	.070	.077	.108	.261	.287	.444	1.07	1.18
Paper Mill Optimization-Closed Loop	.001	.001	.001	.001	.003	.003	.013	.023	.027
Real Time Neural Networks	.19	.19	.163	.232	.232	.198	4.55	4.55	3.88
Reprocessing Uncured Rubber Demonstration	0	.006	.008	0	.016	.023	.003	.078	.113
Solid State Radio-frequency Power Source for Electric Lighting	.168	.424	.434	.756	1.953	1.955	2.78	7.20	7.20
Sulfur Trioxide Cleaning Process for Chip Manufacture	.063	.077	.075	0	0	0	1.18	1.43	1.41
Ultrasonic Tank Cleaning	.008	.226	.274	0	0	0	0	0	.002
Ultraviolet Curing of Fiberglass Sleeving in Wire Manufacture	0	0	0	0	.001	.001	.002	.004	.005
Use of Recovered Plastics	0	.049	.067	0	0	0	.001	.811	1.11
UV Curable Coatings for Aluminum Cans	.002	.003	.002	.006	.008	.005	.033	.041	.024
VOC Control Strategies	.014	.087	.085	.037	.23	.22	.243	1.50	1.46
Wastewater Recycle Reuse in Paint Manufacture	0	0	0	0	0	0	-.002	-.002	-.001
Water-Washed Overspray Paint	.001	.001	0	.003	.001	0	.015	.021	.002
Total	**.27**	**.60**	**.67**	**1.362**	**3.475**	**3.563**	**10.32**	**21.42**	**23.32**

Q355b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A355b. The project benefits would probably not occur without government funding. Many of the projects resubmit proposals that we do not fund in the next year's solicitation. Competition for investment funds is very keen in industry. Interviews with past proposers who did not win indicate that unless they find other sources of funding, the projects do not go forward. At the very least significant delays would occur in implementing the projects while sources of funding were located.

Q356. Page 505 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following NICE-3 performance metrics for FY 1995 and FY 1996:

Measure:

	1995	1996
% of States participating	40	46
% of program cost returned to U.S. Treasury in tax revenue	100	132
$ Leveraging ratio of private to federal dollars	3.8	5
Million $ in private investment funds	10	30
MMTCE Abated	.06	.4

Q356a. Please provide detailed documentation for each of these claimed performance metrics in FY 1995 and FY 1996, including identification of States participating, and DOE funding provided to each State in FY 1995 and FY 1996 for such participation.

A356a.

States participating: Data contained in the following table (Table 1) give proposals submitted by year by State through 1996. Only five States have never submitted a proposal to NICE-3. About 80% of the States submit proposals in any given year. In the first two years of the program, the program was restricted as a pilot program to seven States.

TABLE 1: PROPOSALS SUBMITTED BY STATE UNDER NICE-3

State	1991	1992	1993	1994	1995	1996	Submitted	Awarded
AL	Not Elg.	Not Elg.	0	1	1	1	3	0
AK	Not Elg.	Not Elg.	0	0	0	0	0	0
AR	Not Elg.	Not Elg.	1	0	1	1	3	0
AZ	Not Elg.	Not Elg.	0	2	4	0	6	1
CA	0	9	2	6	17	13	47	9
CO	Not Elg.	Not Elg.	1	1	6	0	8	1
CT	Not Elg.	Not Elg.	2	2	1	4	9	2
DE	Not Elg.	Not Elg.	0	2	2	1	5	2
DC	Not Elg.	Not Elg.	0	0	0	0	0	0
FL	Not Elg.	Not Elg.	0	1	1	1	3	0
GA	Not Elg.	Not Elg.	1	2	3	5	11	2
HI	Not Elg.	Not Elg.	0	0	0	0	0	0
ID	Not Elg.	Not Elg.	1	2	4	3	10	0
IL	1	2	0	3	3	9	18	1
IN	Not Elg.	Not Elg.	1	1	1	2	5	2
IA	Not Elg.	Not Elg.	1	0	2	4	7	0
KS	Not Elg.	Not Elg.	0	1	1	3	5	1
KY	Not Elg.	Not Elg.	1	3	2	0	6	0
LA	1	0	3	0	3	1	8	1
ME	Not Elg.	Not Elg.	1	0	0	1	2	0
MD	Not Elg.	Not Elg.	1	2	6	4	13	2
MA	Not Elg.	Not Elg.	0	4	3	8	15	3
MI	Not Elg.	Not Elg.	2	4	6	6	18	4
MN	Not Elg.	Not Elg.	0	2	2	1	5	2
MS	Not Elg.	Not Elg.	1	0	0	1	2	0

State	1991	1992	1993	1994	1995	1996	Submitted	Awarded
MO	Not Elg.	Not Elg.	0	0	1	2	3	0
MT	Not Elg.	Not Elg.	0	0	0	0	0	0
NE	Not Elg.	Not Elg.	0	0	0	0	0	0
NV	Not Elg.	Not Elg.	0	0	0	1	1	0
NH	Not Elg.	Not Elg.	1	0	1	1	3	0
NJ	1	1	0	1	3	3	9	1
NM	Not Elg.	Not Elg.	0	0	1	2	3	0
NY	1	1	1	4	7	2	16	2
NC	Not Elg.	Not Elg.	0	0	8	6	14	3
ND	Not Elg.	Not Elg.	0	0	1	0	1	0
OH	3	5	3	23	21	17	72	11
OK	Not Elg.	Not Elg.	0	0	0	1	1	0
OR	Not Elg.	Not Elg.	3	2	5	4	14	5
PA	Not Elg.	Not Elg.	2	5	10	10	27	1
RI	Not Elg.	Not Elg.	1	2	0	0	3	0
SC	Not Elg.	Not Elg.	0	3	1	5	9	1
SD	Not Elg.	Not Elg.	0	1	0	0	1	0
TN	Not Elg.	Not Elg.	0	1	1	2	4	1
TX	1	1	2	4	9	3	20	2
UT	Not Elg.	Not Elg.	0	3	5	2	10	0
VT	Not Elg.	Not Elg	0	1	0	2	3	0
VA	Not Elg.	Not Elg.	0	2	3	1	6	1
WA	Not Elg.	Not Elg.	2	2	9	2	15	2
WV	Not Elg.	Not Elg.	1	0	0	0	1	0
WI	Not Elg.	Not Elg.	0	3	2	3	8	1
WY	Not Elg.	Not Elg.	0	1	3	2	6	0
PR	Not Elg.	Not Elg.	0	0	0	1	1	0
VI	Not Elg.	Not Elg.	0	1	0	0	1	0
GM	Not Elg.	Not Elg.	0	0	0	0	0	0
MI	Not Elg.	Not Elg.	0	0	0	0	0	0
SA	Not Elg.	Not Elg.	0	0	0	0	0	0
Total	**8**	**19**	**35**	**98**	**160**	**141**	**461**	**64**

Program cost returned to Treasury: As of 1995 the 41 projects reported savings of 96 million dollars on federal expenditures of 12 million. The 96 million is assumed to be subject to taxation at a corporate average rate of 40%. Based on the above. it is estimated that the tax revenue would be $38 million per year. Our success rate for the projects in the program exceed one third to one half, giving tax revenues of $12 million to $19 million per year. In 1996, the projection is that we will be able to validate the higher successful number of projects.

Ratio of private to Federal dollars: The leveraging ratio for 1995 is in the following table (Table 2); 1996 awards have not been determined yet, but are estimated to have improved the cost-sharing based on an increased cost-share requirement of 55% from industry in the 1995 solicitation. Cost-share is calculated by industrial contribution divided by the total cost of the project.

TABLE 2: COST-SHARE IN 1995 BY PROJECT LISTED BY PARTNER AS OF MARCH 1996

(In $)

FY 1995 NICE-3 Project Title	Location	Cost-Share			
Partner	(State)	Industrial	State	Federal	Total
SO3 Cleaning Process	CA				
Anon		100,000			
Applied Science Consultants		50,000			
Philips Research		380,300			
Matheson Electronics		56,000			
[Note: DOE did not provide name of Partner)		100,000			
Total		686,300	15,890	301,000	1,003,190
Recovered Plastics in Durable	CA				
MBA		296,000			
Geon Co.		5,000			
Philips Research		5,000			
Himont Advanced Materials		5,000			
American Plastics Council		100,000			
Appliance Recycling Centers		5,000			
Krebs Engineering		10,000			
Kice Industries		24,000			
Dorr-Oliver-Grinding Puma		30,000			
Total		485,000	15,890	325,000	825,890
Closed Cycle Bleached Kraft	CA				
Louisiana-Pacific		1,200,000	20,000	425,000	1,825,000
Membrane Filtration-Black	CA				
TriValley		6,625,000			
EPRI		200,000			
University of California		200,000			
Total		7,025,000	15,890	425,000	7,465,890
Brick Kiln-Low Thermal Mass	CA				
Pacific Clay Products		2,680,781			
Southern Cal Edison		2,700			
South Coast Air Quality Mgmt.		146,519			
Total		2,830,000	15,890	350,000	3,195,890
Cathodic Arc Deposition	CA				
Vacuum Plating Technology		108,500	15,890	108,500	232,890
Oxy-Fuel Burners for Steel	IN				
Praxair		239,691			
Bethlehem Steel		339,038			
Total		578,729	75,000	83,500	737,229
Deicing Airplanes	MD				
CCSI, Inc.		400,000	5,000	405,000	810,000
Paper Mill - Closed-Loop	MI				
Simplex Products		336,250			
Resource Recycling Systems		112,000			
HNTB Engineering		45,250			
Western Michigan University		32,500			
Total		526,000	0	400,000	926,000

FY 1995 NICE-3 Project Title Partner	Location (State)	Cost-Share			
		Industrial	State	Federal	Total
Atmosphere Recovery-Heat	MN				
Dow Chemical		39,313			
Dana Corp.		306,125			
Atmospheric Recovery		28,750			
BOC Gases		35,906			
Air Liquide		39,906			
Total		450,000	5,000	268,500	723,500
Brine Reuse-Textile Industry	NC				
Sara Lee Knit Products Corp.		10,600	0	105,996	211,996
UV Curing-Fiberglass	NC				
NATVAR		50,400			
Actinic		11,200			
Total		61,600	2,500	62,500	126,600
Fuel-Based Nitrogen	OH				
IGTCC		44,175			
East Ohio Gas		15,500			
Columbia Gas		15,325			
Unidentified Demo Sites		275,000			
Total		350,000	0	283,500	634,000
Innovative Tech. For Uncured	OH				
Air Products		217,341			
Midwest Elastomers		175,595			
Nelmor		55,140			
Total		448,076	0	400,000	848,076
Pallet Manufact. With	VA				
Birdsong Peanuts		645,700			
Environmental Solutions		645,700			
Total		1,291,400	24,000	425,000	1,740,400
Innovative Blanching	WA				
Key Technology, Inc.		152,759	15,000	167,758	335,517
Ink Jet Recovery and	WI				
Quad Graphics		3,600,000	0	425,000	4,025,000

Million $ in private investment funds: In addition to the existing cost-shares listed, additional resources from outside sources such as EPRI, GRI, banks and Funds, funds are being sought to come up with an additional $10 million in funds in 1996 and $30 million in FY 1997 to fund projects which are turned down for funding by NICE-3.

MMTCE Abated Currently: The million metric tons of carbon equivalent are estimated from a metrics program that tallies the cumulative benefits of projects by year. Numbers for NICE-3 projects are in the table in the answer to Q355a above.

Q356b. Please identify, by contributor, the sources of the $10 million in private investment funds in FY 1995 and $30 million in FY 1996, including the DOE funds provided to each such source.

A356b. See Table 2 in A356a.

Q357. Please provide a listing of the recipients of (i) the $6,000,000 in funding in FY 1995, (ii) the $5,857,000 in FY 1996 funding, and (iii) the requested level of $12,000,000 in FY 1997 for NICE-3.

A357. Recipients of the $6,000,000 in funding for FY 1995 are shown in Table 2 in A356a above. The award winners for the funding in FY 1996 are listed in the immediately following table. The award winners for FY 1997 will not be available until May 1997. Our solicitation runs annually, with awards determined by May of each fiscal year.

1996 NICE-3 Awards with Cost Sharing Information
(in $)

Identifier	Project Title	Federal Cost	Industry/Other
PA-05	New Energy-Efficient Process for Hot-Dip Batch Galvinizing-Steel Vision Team	267,469	326,878
NC-03	A Novel Method to Process Electric Arc Furnace (EAF) Dust into Saleable Chemical Products-Steel and Chemical Vision Teams	425,000	986,332
MA-01	Innovative Textile Printing Process	425,000	792,471
MA-02	Application of High Temperature Materials to a US Capability to Die Cast Copper Motor Rotors-Casting and Foundry Vision Team	425,000	785,741
MI-03	Pre-Curing With Combustion Emissions to Enhance the Emerge Efficiency and Productivity of Concrete Masonry Plants-Chemical Vision Team	382,500	467,500
MI-02	Integrated Recovery System to Reliably Recycle Solvents	400,000	1,733,129
OH-14	Closed Loop Recycling of Aluminum Dross/Saltcake Landfill Waste: Manufacturing Industrial & Commercial Ceramic Products from Recovered Nonmetallic Waste-Aluminum Vision	400,000	900,000
TN-01	Lithographic Ink Reformulation Technology(LIRT)-Chemical Vision Team	393,029	626,400
LA-01	Advanced Process Analysis for Source Reduction in the Sulfuric Acid Petroleum Refining Alkylation Process-Refining Vision Team	273,962	334,844
NY-01	Demonstration of an Innovative Scrap Decoater for the Metals Industry-Metals Vision Team	425,000	1,149,917
CT-03	High Efficiency Waste Minimizing Plating Barrel-Chemical Vision Team	390,400	694,358
KS-02	Energy and Waste Reduction in the Wood Fiber and Fuel Industry Utilizing a Long Wave Length Catalytic Infrared Drying System-Pulp and Paper Vision Team	346,000	547,000

Identifier	Project Title	Federal Cost	Industry/Other
SC-01	Patented New Chemistry Lowers Power and Bleaching Requirements, Increases Yield for Wood Pulping-Pulp and Paper Vision Team	418,000	511,703
OR-01	Waste Heat Recovery to Power Low Temperature Engine for Electrical Generation-Crosscut	425,000	535,000
CA-04	Gas-Fueled Chemical Heat Pump Performance Confirmation and In-Service Demonstration-Chemical Vision Team	332,953	769,077
MN-01	Closed-Loop Fiber Glass Reinforced Plastic Recovery in Spraying Application	206,000	253,600
UT-01	Use of Fine Particulate Materials in Steel-Making Processes	225,000	340,000
17 Awards	**Totals**	**$6,160,313**	**$11,753,950**

Q358. For each recipient of NICE-3 funds identified in the response to question 357 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A358. Cost share for the 1995 and 1996 projects are given in Table 2 in A356a and the table in A357 above. FY 1997 awards information on cost share will not be available until May 1997.

Q359. For those NICE-3 funding recipients identified in the response to question 357 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A359. All awards were made on a competitive basis. No non-competitive awards were made. All industrial awardees have been determined from a competitive range of proposals. National Lab fundings were awarded as Field Task Proposals under an master, competitively awarded contract with the DOE Laboratory.

Q360. On page 511 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated in the FY 1995 column for NICE-3: "Benefits of the NICE-3 program have estimated to include Energy savings of 720 Billion BTU/Year, Waste reduction of 180 Million tons/Year, and Jobs saved/retained equal to about 14,400 by 200 [sic]."

Q360a. Please provide detailed documentation of these claims, including the peer review process undertaken.

A360a. A large spreadsheet has been constructed to estimate the benefits in out years of projects. The above tally is for current projects without replication to other sites and without any projects purchased beyond 1995. The spreadsheet file (in Lotus 123) is attached. Peer review was undertaken by Energetics in 1995 and by A.D. Little in FY 1996. Although some projects' benefits have been lowered based on a detailed review, the numbers quoted as benefits are for on the ground projects, and are solid.

[Note: DOE did not include the spreadsheet file referred to above.]

Q360b. Please document why these benefits would not occur in the absence of DOE funding.

A360b. The project benefits would not occur without government funding. Many of the projects resubmit proposals that we do not fund in the next year's solicitation. Competition for investment funds is very keen in industry. Interviews with past proposers who did not win indicate that unless they find other sources of funding. the projects do not go forward.

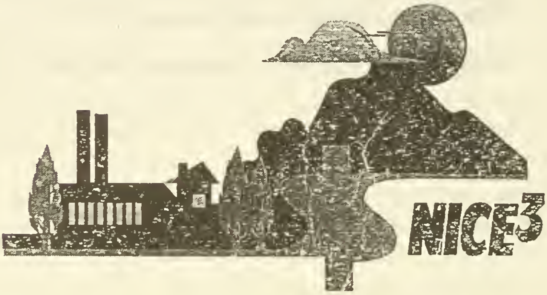
Q361. Please describe all NICE-3 projects for the period FY 1994-FY 1997, provide both the DOE and private-sector funding for each.

A361. See attached Quarterly report. Descriptions of new projects are not available.

ENERGY EFFICIENCY & RENEWABLE ENERGY

December 1995
Quarterly Project Status Report

NICE^3 Program



Status Report of Projects
Managed by DOE-GO

For
Office of Industrial Technologies
Technology Transfer Division
Division EE-223

U.S. Department of Energy
Golden Field Office
Golden, Colorado

Foreword

The Department of Energy's (DOE's) Office of Industrial Technologies (OIT) Technology Transfer Division (EE-223), has delegated certain project administration responsibilities for the NICE^3 Program to the Golden Field Office (GO). GO's administration includes writing status reports on each project and compiling this information into monthly and quarterly status reports. The monthly report is distributed to specific EE-222/223 program managers. The quarterly report has a wider distribution within EE-222/223, the Regional DOE Support Offices, and to NICE^3 related U.S. EPA personnel. This report will be generated four times per year.

THIS REPORT IS FOR INTERNAL USE ONLY AND NOT INTENDED FOR GENERAL DISTRIBUTION. MATERIAL CONTAINED IN THIS REPORT MAY BE PROPRIETARY.

Comments on the Quarterly Report or requests for additional project information can be directed to:

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NICE^3 PROGRAM

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Ultrafiltration of Commercial Laundry Wastewater (OR, Red Lion Inns) 1995

NICE^3 PROJECT DATA

Direct Copper Plating

RECIPIENT: Continental Circuits Corp

RECIPIENT PROJECT DIRECTOR: David Connors (602) 470-8193

STATE: Arizona

EPA / DOE REGION: IX

CONGRESSIONAL DISTRICT: AZ-01

CONGRESSIONAL REPRESENTATIVE: Matt Salmon (R)

SENATORS: John Kyl (R) John McCain (R)

PROJECT NUMBER: 94-AZ-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Az. Dep.t of Environmental Quality
Todd Dorris (602) 207-4337

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: This project concerns the copper plating of printed circuit boards with emphasis on how to plate a non-conductive substrate and how to plate the through holes. Currently the system of choice is electroless copper plating because it can plate the through holes where conventional electroplated copper cannot. Eliminating electroless copper plating would eliminate the formaldehyde used by this process and would reduce or eliminate the use of cyanide.

PROCESS DATA: 650,000 PANELS / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	2.52×10^9 Btu/yr/unit	1.51×10^9 Btu/yr/unit	1.0×10^{12} Btu/yr
Environment (Waste Reduction)	286 tons/yr/unit	100 tons/yr/unit	20,000 tons/yr
Economics (Payback)	---	1 yr	—

TECHNICAL PERFORMANCE

Direct Copper Plating

Background

Electroless copper plating of through holes has been the standard, accepted process for metallization of plastic substrates in the United States since the 1950's. The electroless copper process metallizes the drilled holes so that subsequent electrolytic copper plating can be accomplished. The electroless copper process waste stream is generated as a result of bath growth and elevated contaminant levels. Bath growth occurs when the active ingredients are depleted and then replenished with fresh chemistries. Elevated contaminate levels occur over time, requiring a bath change out. Thus a waste stream is generated that contains formaldehyde and cyanide based components, both of which are very toxic chemicals which must be handled and treated.

Direct plate technology, on the other hand, is a standard through-hole plating process in many circuit board manufacturing facilities outside the U.S. The advantages of the direct plate process is through-hole plating without the use of electroless copper chemicals. At the same time the use of chemicals containing formaldehyde and cyanide from the through-hole plating process is eliminated.

Continental Circuits Corporation proposes to convert the electroless copper through-hole plating process to a non-electroless (direct plate) copper process. The direct plate will accomplish the same plating function on the through-holes without the use of formaldehyde or cyanide based chemicals. The direct plate system uses an ultra fine colloidal activator in a series of process steps that render non-conductive surfaces conductive, thus allowing surface plating.

Technical Progress

The ATOTECH Direct plate process continues to be the chosen direct plate process. Finalization of plans to modify an existing electroless line to a direct plating line were completed and the modification began in mid-November. Test results from direct plate circuit board panels showed that the direct plate process is capable of passing quality assurance tests to the same level using conventional electroless copper plating techniques. Limited production runs of the newly modified direct plate process line began in November 1995 and will continue through April 1996. A site visit was conducted with State and RSO personnel on November 12, 1995 at the CCC site. More rigorous testing that more closely duplicates production conditions and product standards will commence in January 1996 and continue until April 1996.

Technical Transfer

Continental Circuits Corporation is the first printed circuit board manufacturing company (of its size) in the United States to investigate and develop direct plate technology in the production process. Other major printed circuit board manufacturers are closely monitoring this development effort with full cooperation from Continental Circuits Corporation. The technology will lend itself well to a marketing plan similar to the following:

1) Continental Circuits Corporation proves that the technology is viable for manufacturing printed circuit boards at its facility; 2) Continental Circuits Corporation informs its customers and other target market segments of the progress of development; 3) As a result of exposure through the NICE[3] grant program, the DOE and EPA place information relating to the technology into one or more alternative technology databases; 4) Continental Circuits Corporation provides technology transfer with other printed circuit board manufacturers; and 5) Continental Circuits Corporation provides site visits to its facility so that other companies can understand the direct plate technology and its applications.

Commercialization: None to date. **Benefits:** None to date.

Milestones:

Milestone	Planned	Actual / Revised
Evaluate Ardox Process	2/10/94	1/95
Evaluate Chrimson Process	4/15/94	1/95
Evaluate Electrochemicals	6/1/94	1/95
Select Most Effective Process	8/10/94	8/95
Order Vertical Components	10/15/94	
Take Delivery of Vertical Components	12/15/94	
Install and Set-up Vertical Components	2/15/95	
Order Horizontal Components	5/15/95	
Take Delivery of Horizontal Components	8/15/95	
Install and Set-up Horizontal Components	11/15/95	
Pre-production Review and Evaluation	4/15/96	
Production and Review Evaluation	7/15/96	
Project complete	8/96	

Budget & Cost Sharing:

Funding Source	%	Amount, $
DOE / EPA	50	220,000
State	5	20,000
Continental Circuits	45	200,000
Total	100	440,000

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* POC for project description updates.

NICE^3 PROJECT DATA

SO_3 Gas-Phase Cleaning Process in the Manufacture of Semiconductors

RECIPIENT: ANON, Inc.

RECIPIENT PROJECT DIRECTOR: Eric Levinson (408) 428-2860

STATE: California

DOE REGION: IX

CONGRESSIONAL DISTRICT: CA-16

CONGRESSIONAL REPRESENTATIVE: Zoe Lofgren (D)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 95-CA-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Energy Commission
David Jones (916) 654-4554

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: The technical goal of this project is to prove to the semiconductor industry the effectiveness of our gasphase, anhydrous, sulfur trioxide process as a means of removing photoresist and other organic materials from semiconductor wafers with line geometries below 0.3 micron. The process offers dramatic reductions in hazardous material usage coupled with improvements in effectiveness in industries which use liquid, organic cleaning agents on substrates containing very small features.

PROCESS DATA: REPLACING FOUR, SIX-GALLON SINKS CONTAINING H_2SO_4

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	37.5×10^9 Btu/yr/unit	0	117.6×10^{12} Btu/yr
Environment (Waste Reduction)	674.8 tons/yr/unit	2.8 tons/yr/unit	2.6×10^6 tons/yr
Economics (Payback)	—	1.4 months	—

TECHNICAL PERFORMANCE

SO_3 Gas-Phase Cleaning Process in the Manufacture of Semiconductors

Background

Photoresist stripping is fast becoming a growing concern for semiconductor wafer manufacturers. Photoresist, a photo-sensitive organic material, is used at many stages in the manufacture of semiconductors to "maskoff' areas on the wafer for exposure to specific production processes. In order to fully clean the hardened photoresist from very small grooves and crevices on the wafer, industry presently uses "dry" and "wet" stripping methods, often in combination. "Dry" stripping equipment, sometimes called dry-ashing, removes photoresist generally by exposing wafers to a high-energy oxygen-ion plasma generated with radio-frequency or microwave energy which first oxidizes and then "knocks off" the photoresist. However, these high-energy methods also introduce radiation and charging damage which hurts semiconductor yield and reliability.

"Wet" stripping equipment typically uses large quantities of hot acid solutions or organic solvents to remove resist. But the wet methods are not very effective in removing resists which are hardened in the processing step, or which cover very small lines and crevices. Management of the wet process hazardous-chemical waste-stream is becoming more and more difficult.

ANON's $S0_3$ gas-phase cleaning technology (ANON holds all patent rights) offers manufacturers a process which is both technically and economically superior to the existing cleaning methods (wet stripping and dry plasma ashing). It also eliminates the need for using the large volumes of toxic chemicals which the industry currently uses and the consequent requirement to manage the resulting waste stream. The "wet" and "dry" processes currently in use by the semiconductor industry for resist removal are barely adequate to meet todays' cleaning requirements. Furthermore, neither of the current wet or dry processes adequately meet the manufacturing needs of the sub-0.35 micron semiconductor devices which are being designed today.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be complete by February 1, 1996. Anon has commenced work on the project.

Commercialization: None to date. **Benefits:** None to date.

Technical Transfer

The concept of using SO_3 in gas-phase as a cleaning agent for substrates has met qualified acceptance by a variety of technical and industry professionals. The acceptance of the concept has been demonstrated by the supporting relationships ANON has been able to establish with PHILIPS LABORATORIES, MATHESON ELECTRONICS PRODUCTS, and others.

Our estimates are that in 1996 there will be about 11,731 wet stripping units in use in North America. We expect that about 27% of these units will be potentially replaceable with our novel gas-phase process unit. By the year 2010, with a very conservative growth rate of 3% each year, there will be 4,889 units available for replacement by our unit.

ANON is well along the path of being able to demonstrate the technology to the industry at large and to specific, potential customers who are interested in evaluating the effectiveness of this novel cleaning process. ANON has already constructed the first exposure unit required to implement the marketing plan. The plan has been developed with the assistance of NV PHILIPS LABORATORIES who will take part in evaluating and improving the process. Potential customers with whom ANON has already established business relationships include: PHILIPS ELECTRONIC PRODUCTS (Div. of NV PHILIPS), INTEL, QUALITY SEMICONDUCTOR, AMD, INTEGRATED DEVICE TECHNOLOGY, and HEWLETT PACKARD.

Milestones

Milestone	Planned	Actual / Revised
Complete design of demonstration unit	10/95	
Complete first demonstration to customers	1/96	
Conduct tests on production and wafers	2/96	
Install test unit at industrial site	5/96	
Complete analysis of results from industrial tests	6/96	
Modify process and reinstall at industrial sites	8/96	
Analyze test results and write draft final report	4/97	
Submit final report - Project complete	6/97	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	30	301,000
State	2	15,890
Industry	68	718080
Total	**100**	**1019190**

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NICE^3 PROJECT DATA

Use of Recovered Plastics from Durable Goods Manufacturing

RECIPIENT: MBA Polymers, Inc.

RECIPIENT PROJECT DIRECTOR: Michael Biddle
(510) 704-7585

STATE: California

DOE REGION: IX

CONGRESSIONAL DISTRICT: CA-1

CONGRESSIONAL REPRESENTATIVE: Frank Riggs (R)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 95-CA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Energy Commission
David Jones (916) 654-4554

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Manufacturers of plastic products generate scrap at the beginning and end of production runs, during equipment upsets, and during secondary processing. Any recovery which is accomplished is done manually. MBA will demonstrate an energy and cost effective way for manufacturers of durable plastic products to recover and reuse scrap plastic. This will be accomplished through an integrated process involving size reduction, materials liberation, materials separation, and cleaning.

PROCESS DATA: 1000 TONS OF RECYCLED PLASTICS

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	80×10^9 Btu/yr/unit	5×10^9 Btu/yr/unit	45×10^{12} Btu/yr
Environment (Waste Reduction)	3941 tons/yr/unit	1177 tons/yr/unit	1.66×10^6 tons/yr
Economics (Payback)	—	1.3 yr	—

TECHNICAL PERFORMANCE

Use of Recovered Plastics from Durable Goods Manufacturing

Background

Manufacturers of plastic products generate scrap at the beginning and end of production runs, during equipment upsets, and during secondary processing. For simple plastic products, typically packaging materials and other single material goods, this industrial scrap is readily recovered. However, for more complicated products, particularly multi-component durable goods, the plastic scrap is often contaminated with paint, fillers, metals, foams, and other materials (including mixed plastic types) which make recovery by the manufacturer difficult. Any recovery which is accomplished is done manually. The approximately 4,000 million pounds of plastic used to produce automobiles, appliances, and electrical and electronic equipment (excluding wire and cable) is the target for this project. The plastic scrap from the manufacture of these products is most often placed in landfills.

Our concept is an energy and cost effective way for manufacturers of durable plastic products to recover and reuse the scrap plastic, either as an integral part of large manufacturing processes or at central locations for smaller manufacturers. The manufacturer has two process options: landfill the scrap plastic and remake the rejected parts with virgin plastic or recover the scrap plastic and use it to remake the rejected parts.

The technical goal of this project is the commercial demonstration of several key advanced size reduction, materials liberation, materials separation, and cleaning technologies for plastics which combine to produce an advanced plastics recycling system that will offer many capabilities not available today, including: 1) paint, coatings and surface contamination removal and/or compatibilization; 2) enhanced size reduction throughput, equipment wear, energy consumption and particle size and shape control; 3) reduced product and side-stream contamination; 4) enhanced process control of heavy media systems for multi-material separations; 5) advanced material separation capabilities; 6) closed, high throughput, efficiency and simplicity; and 6) accommodation of pre-shredded mixed materials.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be concluded by February 1, 1996. MBA has begun work on the project.
Commercialization: None to date. **Benefits:** None to date.

Technical Transfer

The commercialization potential for this project is widespread. MBAP has developed this technology with partial funding from APC and in partnership with the major stakeholders in the automotive, computer and business equipment and major appliance industries (such as Ford, GM, Chrysler, Digital Equipment Corporation, Hewlett Packard, IBM, Compaq, and Apple). Although they have focused on only three industries, success of this technology will undoubtedly lead to applications in other industries, including building and construction, furniture, and packaging.

MBAP will transfer the technology package to manufacturing companies who want to install their own systems and assist in the construction and start-up of process plants. We anticipate that the technical transfer of this unique system will be made by a combination of licensing, free transfer and captive installations. Our projection is for 30 installations within five years of 2 million lbs/yr capacity units, and installations at the rate of approximately 50 per year from the year 2000 to 2010 (or 10 installations per year of 10 million lbs/yr capacity units). In addition MBAP will attempt to expand the technology outside the United States. The waste challenges faced by other developed countries with high population densities are much more significant than in the U.S. making this technology very attractive from an economic, resource conservation and waste avoidance standpoint.

Milestones

Milestone	Planned	Actual / Revised
Completed pilot trial and Phase I engineering for commercial plant	9/95	
Detailed engineering completed including equipment specifications	12/95	
Site preparation and equipment purchase complete	3/96	
Equipment installed and shakedown process begins	6/96	
Unit fully operational	9/96	
Draft report submitted to DOE	12/96	
Final report submitted - Project complete	3/97	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	39	350,000
State	2	15,890
Industry	89	2,830,000
Total	**100**	**3,180,890**

Points of Contact

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Industry:

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* POC for project description updates.

NICE^3 PROJECT DATA

Closed Cycle Bleached Kraft Pulp Production

RECIPIENT: Louisiana-Pacific Corp.

RECIPIENT PROJECT DIRECTOR: Kirk Girard (707) 443-7511

STATE: California

DOE REGION: IX

CONGRESSIONAL DISTRICT: CA-1

CONGRESSIONAL REPRESENTATIVE: Frank Riggs (R)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 95-CA-4

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Energy Commission
David Jones (916) 654-4554

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Two bleaching technologies are evolving to achieve pollution emission reduction. One uses no chlorine containing compounds and is labeled TCF bleaching ("Totally Chlorine Free"). The other uses chlorine dioxide (ClO_2), and is labeled ECF bleaching ("Elemental Chlorine Free"). The Louisiana-Pacific Corporation (LPC) Samoa Pulp Mill in California is leading the development of TCF Closed Cycle bleaching in the U.S. This project will allow LPC to become the first full scale TCF Closed Cycle Kraft pulp mill in the U.S.

PROCESS DATA: BLEACHED KRAFT PULP MILL PRODUCING 245,000 TONS OF PULP / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	1.3 x 10^{12} Btu/yr/unit	765 x 10^9 Btu/yr/unit	324 x 10^{12} Btu/yr
Environment (Waste Reduction)	12.7 x 10^6 tons/yr/unit	0	7.6 x 10^9 tons/yr
Economics (Payback)	---	TBD	---

TECHNICAL PERFORMANCE

Closed Cycle Bleached Kraft Pulp Production

Background

The United States Pulp and Paper Industry is the fourth largest consumer of fossil fuels in the country and the single largest consumer of process water. Each year, the industry consumes over three quads of energy and discharges approximately 1.5 trillion gallons of wastewater.

The wastewater of greatest concern from a pollution standpoint is that generated during the pulp bleaching process. The wide use of chlorine compounds for bleaching results in discharge of priority pollutants such as chlorinated dioxins. The origin of toxicity in pulp mill effluent has been attributed to the presence of adsorbable organic (AOX), a general measure of chlorinated organic compounds. The potential for recycle of bleaching wastewater has been limited because of the corrosivity of the residual chlorine compounds contained in the wastewater. As a result, bleach plant wastewater is discharged, releasing contaminants, residual bleaching chemicals, and energy to the environment.

Two bleaching technologies are evolving to achieve pollution emission reduction. One uses no chlorine containing compounds and is labeled TCF bleaching ("Totally Chlorine Free"). The other uses chlorine dioxide (ClO_2), and is labeled ECF bleaching ("Elemental Chlorine Free"). These recent advancements in alternative bleaching technologies have made recovery of bleach plant wastewater feasible and most promising approach to energy conservation, water conservation and pollution prevention. Recycle and recovery of all pulping and bleaching process wastewaters is termed "Closed Cycle."

The Louisiana-Pacific Corporation ("L-P") Samoa Pulp Mill in California is leading the development of TCF Closed Cycle bleaching in the U.S. The Samoa Mill, constructed in 1964, produces an average of 650 tons of bleached Kraft pulp per day from waste wood chips generated by local sawmills. In January 1994, the Samoa Mill became the only North American Kraft pulp mill to produce bleached pulp without the use of chlorine or chlorine containing compounds on a permanent basis. The Samoa Mill achieves this by using hydrogen peroxide and oxygen. TCF bleaching presents unique opportunities for Closed Cycle operation of the Samoa Mill's pulping and bleaching process. The successful commercialization of a full scale TCF Closed Cycle Kraft pulp mill in the U.S. will have worldwide implications.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be completed by February 1, 1996.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

Dissemination of the project results to other U.S. pulp mills will be accomplished through technical publications, public promotion, participation in industry conferences, mill tours, and regulatory forums. The pace of the project is critical. The Samoa Pulp Mill has the real opportunity to be the first Kraft pulp mill in the world to attain Closed Cycle operations. If the U.S. is the first to achieve this milestone, the achievement will be universally reported in news media, industry journals and trade circles.

Milestones

Milestone	Planned	Actual / Revised
Install and test split showers on chelation stage and post 02 washers	2/96	
Conduct mill tests of fiber line recycle and use of filtrate in liquor preparation	10/96	
Complete detailed engineering design estimates to compare evaporation to recaustization upgrade	10/96	
Install and evaluate full scale green liquor dregs removal and dewatering system	2/97	
Recycle and recover 100% of peroxide stage filtrates	3/97	
Design spill prevention, energy mgmt., metals mgmt., and regulatory reform data system	11/96	
Install system hardware	2/97	
Install and evaluate system software	8/96	
Prepare and submit final report - Project complete	3/97	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	23	425,000
State	11	175,000
Industry	66	1,600,000
Total	**100**	**2,200,000**

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* POC for project description updates.

NICE^3 PROJECT DATA

Membrane Filtration to Process Black Ripe Olives

RECIPIENT: Tri Valley Growers

RECIPIENT PROJECT DIRECTOR: Duane Rohrer (209) 572-5980

STATE: California

DOE REGION: IX

CONGRESSIONAL DISTRICT: CA- 18

CONGRESSIONAL REPRESENTATIVE: Gary A. Condit (D)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 95-CA-3

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Energy Commission
David Jones (916) 654-4554

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Tri Valley Growers will design and construct a black ripe olive operation in which all water, chemicals and olive pomace are recycled back into the operation or converted into a useful byproduct. It is proposed to treat one million gallons per day of process water and then recycle it back into the olive operation. Innovations adopted in the plant operation will reduce the volume of water used, reduce chemical requirements, and enhance yield.

PROCESS DATA: PROCESSING 20,000 NET TONS OF RAW PRODUCT

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	155×10^9 Btu/yr/unit	135×10^9 btu/yr/unit	9.5×10^{12} Btu/yr
Environment (Waste Reduction)	863,340 tons/yr/unit	7,607 tons/yr/unit	385×10^6 tons/yr
Economics (Payback)	—	9.4 yr	–

TECHNICAL PERFORMANCE

Membrane Filtration to Process Black Ripe Olives

Background

Current technology to process black ripe olives generates millions of gallons of liquid waste which contains a high concentration of salts. Adoption of the proposed technology will generate by-products instead of waste and, as a result, eliminate the potential of contaminating groundwater with unacceptable levels of salt. Adoption of this technology has the potential to save the olive industry.

Tri Valley Growers will design and construct a black ripe olive operation in which all water, chemicals, and olive pomace are recycled back into the operation or converted into a useful byproduct. Testing of equipment and design has been successfully completed, and has demonstrated the feasibility of this proposal. It is proposed to treat one million gallons per day of process water and then recycle it back into the olive operation. Treatment will consist of a 50 micron screen followed with ultrafiltration and, finally, reverse osmosis. Concentrate from the ultrafiltration and reverse osmosis will be dehydrated by means of evaporation followed with a spray dryer. This dried by-product is being examined for a number of potential applications including animal feed, fermentation, or to be included as an additive compound in other products. A second by-product will be olive pomace, which consists of olive pits and olive material. Olive pomace which has a fuel value of 9200 BTU's per pound will be utilized as a fuel in a biomass cogenerator.

Prior development of this technology has been successfully accomplished in the reclamation of sea water for drinking water. Studies by the University of California at Tri Valley Growers and twelve other food processing operations have established the feasibility of transferring this technology to the olive industry as well as to other food processing operations. Application of this technology to the processing of fruits and vegetables will benefit from the successful completion of this proposed project.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be complete by February 1, 1996.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

Successful operation of the proposed technology has been demonstrated in pilot studies and test commercial studies at Tri Valley Growers. These efforts, together with the proposed project, will enhance commercialization of the technology by helping to show that it works. Commercialization will be further enhanced with a wide involvement by industry, government, utilities, universities and suppliers. Groups which include the University of California at Davis, Electric Power Research Institute, Pacific Gas and Electric, California League of Food Processors (CLFP), National Food Processors Association (NFPA), CLFP/NFPA Industry Advisory Technical Committee, and DOE Battelle Pacific Northwest Laboratories are currently working together to demonstrate and implement this technology in the food industry where the need exists.

Implementation of this technology has had to wait for the development of improved membranes. In addition, knowledge of the requirements for pretreatment and operation parameters for membranes had to be developed. Development of the technology and the need in the food industry is now at that juncture where it is ready for commercialization. A commercial application as proposed here will greatly enhance the introduction of this technology. Tri Valley Growers will become involved in the transfer of this technology to other companies through open houses, presentations at professional meetings, and reports.

Milestones

Milestone	Planned	Actual / Revised
Finalize construction design	10/95	
Complete construction	7/96	
Startup and shakedown	9/96	
Unit fully operational	12/96	
Evaluate unit operation	3/97	
Submit final report to DOE	6/97	
Project complete	7/97	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	5	425,000
State	<1	15,890
Industry	95	7,025,000
Total	**100**	**7,465,890**

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* POC for project description updates.

NICE^3 PROJECT DATA

Innovative Design of a Brick Kiln Using Low Thermal Mass Technology

RECIPIENT: Pacific Clay Brick Products

RECIPIENT PROJECT DIRECTOR: Dave Hellingsworth (714) 674-2131

STATE: California

DOE REGION: IX

CONGRESSIONAL DISTRICT: CA-43

CONGRESSIONAL REPRESENTATIVE: Ken Calvert (R)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 95-CA-5

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Energy Commission
David Jones (916) 654-4554

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Pacific Clay will demonstrate an innovative kiln design that will use less natural gas to achieve the same end product, while reducing its variable manufacturing costs and drastically improve its competitiveness both domestically and internationally. This new kiln technology will use less electricity and natural gas and will result in reduced NOx air pollution emissions. The new design will combine low thermal mass technology with state of the art controls, combustion technologies and monitoring equipment.

PROCESS DATA: ONE KILN - 12 MILLION BRICKS /YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	287.5 Btu/yr/unit	129 x 10^9 Btu/yr/unit	36.8 x 10^{12} Btu/yr
Environment (Waste Reduction)	15,850 tons/yr/unit	7500 tons/yr/unit	3.9 x 10^9 tons/yr
Economics (Payback)	---	3.3 yr	---

TECHNICAL PERFORMANCE

Innovative Design of a Brick Kiln Using Low Thermal Mass Technology

Background

When using a conventional tunnel kiln to manufacture bricks, the key factors that have been of concern are temperature and residence time in the kiln. Other factors that must be considered when using a tunnel kiln are the evenness of heat penetration from the outside to the inside of the mass of clay being fired. Ideally, you want to get good heat penetration into the center of the stack of bricks being fired without overheating the bricks on the exterior of the stack. Another factor that must be considered when using a tunnel kiln is the need for energy efficiency in the operation of the kiln. Historically, brick kilns have been lined with refractory brick. Refractory brick has the ability to withstand exposure to high repeated temperatures for sustained periods of time without cracking and disintegrating. However, refractory brick absorbs a tremendous amount of heat, thus lowering the efficiency of the kiln in that more heat goes into the walls of the kiln and less into firing the bricks that are being manufactured.

The technical goal of this project is to utilize Low Thermal Mass (LTM) materials, a new kiln profile, and highly efficient combustion equipment and a comprehensive control and monitoring system to achieve the optimum available performance for a tunnel furnace/kiln. The achievement of this goal will make this technology commercially available for the clay products and related industries.

The low profile construction will make this equipment particularly adaptable for the firing of other clay products which cannot be stacked and would normally have to be racked to be economically processed in a tunnel kiln. Significant savings in time and flexibility of operation are anticipated through the operation of the new kiln as its low thermal mass characteristics coupled with the quality of control previously unavailable will allow rapid heat up and cooling, individual zone control and faster throughput of smaller batches. The anticipated firing time in the new kiln is t 6 hours (as compared to over 40 for the existing kiln). Other innovations that will be incorporated include a positive air interlock at the entrance to the kiln so that the kilns entrance temperature remains stable. To minimize the tendency for ambient air to be drawn into the space between kiln cars, an undercar pressure balance system is provided at the end of the kiln.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be complete by February 1, 1996.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

The technologies to be utilized to create this state of the art kiln are made up of previously proven techniques and materials. They have however never been brought together in this innovative way for a use within the clay products industry.

While the industry group is fairly conservative with respect to changing the way it produces its products it is nonetheless generally aware of factors that could affect its performance. Once one manufacturer has adopted and proved a manufacturing benefit it soon becomes an industry standard. In addition, many of the kilns in operation throughout the US are 40 or more years old and hence have high maintenance as well as high operating costs. They are increasingly difficult to adapt to the changing environmental impact mitigation demands required by legislation this makes the adoption of this new technology more compelling.

It is anticipated that the technical transfer of this integrated design concept of low mass construction, high efficiency combustion design coupled with sophisticated control and monitoring equipment will be made by the inclusion of this installation as a case study to be used as an editorial in trade publications. The manufacturer (Swindell Dressler) will use the site as a flagship example in marketing activities to promote further penetration. The CA Energy Commission and CA EPA will also use the site as a published example of energy efficiency and P2 in an economically viable setting.

Milestones

Milestone	Planned	Actual / Revised
Begin design	9/95	
Approval of 50% design	2/96	
Begin factory fabrication	3/96	
On-site construction begins	8/96	
Unit fully operational	3/97	
Evaluate energy/waste benefits	5/97	
Final report submitted - Project complete	11/97	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	11	350,000
State	<1	15,890
Industry	89	2,830,000
Total	100	3,195,890

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* POC for project description updates.

NICE^3 PROJECT DATA

Decorative Finishing Using Cathodic Arc Deposition Technology

RECIPIENT: Vacuum Plating Technology Corp.

RECIPIENT PROJECT DIRECTOR: David Wong (408) 998-8998

STATE: California

DOE REGION: IX

CONGRESSIONAL DISTRICT: 16

CONGRESSIONAL REPRESENTATIVE: Zoe Lofgren (D)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 95-CA-6

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Energy Commission
David Jones (916) 654-4554

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Vacuum Plating Technology has developed a technology that will apply the gold color, polished brass or chrome finish on products. This technology, called Cathodic Arc Plasma (CAP) deposition will enable manufacturers to obtain a more attractive and durable finish using less energy and without the use of toxic chemicals and eliminate VOC emissions at the same time. This technology is intended to replace the chemical electroplating and after plate varnish process that is currently used.

PROCESS DATA: 1.56 MILLION DECORATIVE PRODUCTS/YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	1.345×10^9 Btu/yr/unit	0.753×10^9 Btu/yr/unit	1×10^{12} Btu/yr
Environment (Waste Reduction)	5330 tons/yr/unit	55 tons/yr/unit	9.0×10^6 tons/yr
Economics (Payback)	---	4.4 years	—

TECHNICAL PERFORMANCE

Decorative Finishing Using Cathodic Arc Deposition Technology

Background

Vacuum Plating Technology has developed a technology that will apply the gold color, polished brass or chrome finish on products. This technology, called Cathodic Arc Plasma (CAP) deposition will enable manufacturers to obtain a more attractive and durable finish using less energy and without the use of toxic chemicals and eliminate VOC emissions at the same time. The CAP process, a branch of Physical Vapor Deposition technology (PVD) can deposit a thin layer (about I micron thick) of Titanium Nitride (TiN), Zirconium Nitride (ZrN), Titanium Carbide (TiC), or about half micron of Chrome. This technology is intended to replace the chemical electroplating and after plate varnish process that is currently used.

Many consumer products require an attractive surface finish to make it appealing and marketable. Cars, appliances, watches, jewelry, etc. are sold not only on the basis of its functionality but most importantly on esthetic and surface finish quality and durability.

The challenge was to build PVD equipment and to develop the processes that can produce a protective coating, consistently and in metal fabrication environment, that is also decorative so that the PVD coating can replace the lacquer finish on high end brass articles and replace the two steps of brass electroplate and lacquer finish on lower end non-brass products. Vacuum Plating Technology Corporation has developed the equipment and the processes to do just that.

Cathodic Arc Plasma Technology offers many advantages over traditional methods because:

- The resultant finish is more attractive and has good weather and abrasion resistance.
- It will reduce the use of toxic chemicals in electroplating.
- It eliminate the VOC emission from the lacquer process used by the target industry groups.
- It is a one step process that replaces the brass electroplating and lacquer finish.
- It will cut energy consumption by about 60%.
- It does not produce hazardous waste.
- Spent source material can be recycled to produce new arc sources.
- It will cut waste generation and disposal costs.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be complete by February 1, 1996.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

Once system field testing is complete, the information gained from this cathodic plasma arc deposition system for decorative finishes complete with automated monitor and control system will be published in trade magazines, trade conferences and symposiums. This equipment will then be installed at VPT's facility to be used to perform demonstration tests and to produce samples to promote this technology to prospective customers. The California Energy Commission and the California EPA under the NICE[3] program are also proposing to use the field test case study as a published example of how to achieve economic advantage through the use of innovative technology that conserves energy and protects the environment. The group will be active participants in the promotion of this technology to targeted industry groups within the state of California.

Data published in the 1992 edition of the Ward's Business Directory of US Private and Public Companies indicate that there are 805 companies nationwide with our targeted SIC codes of 3429, 3432, 3471, or 3645. These companies combine for $20,809 Million of sales in 1992. In addition to this, there are a total of 334 companies nationwide with 1992 sales of $9,718 Million that have 3873, 3911, 3914, and 3961 which are our secondary targets. All off these companies use the decorative brass finish, therefore, they can use CAP technology to save money and energy.

Milestones

Milestone	Planned	Actual / Revised
Specifications complete	9/95	
Approval of design	11/95	
Completion of Electrical Engineering	11/95	
Completion of fabrication	12/95	
Completion of software	12/95	
Completion of debugging	1/96	
Completion of trial run	2/96	
Product ready for market	3/97	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	47	108,500
State	7	15,890
Industry	46	108,500
Total	100	232,890

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NICE^3 PROJECT DATA

UV-Curable Coatings for Aluminum Can Production

RECIPIENT: Coors Brewing Co.

RECIPIENT PROJECT DIRECTOR: Erik Donhowe (303) 277-2282

STATE: Colorado

EPA / DOE REGION: VIII

CONGRESSIONAL DISTRICT: CO-6

CONGRESSIONAL REPRESENTATIVE: Dan Schafer (R)

SENATORS: Ben Campbell (D) Hank Brown (R)

PROJECT NUMBER: 93-CO-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Colorado Office of Energy Conservation
Tom Brotherton (303) 620-4292

DOE SUPPORT OFFICE: Willie Cain (303) 231-5750 x126

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: Conventional technology for aluminum can coatings uses solvent-based printing and over-varnish coatings that are applied to the aluminum and then cured (dried) by convective heat and mass transfer in gas-fired ovens. Coors uses coating materials that cure when exposed to ultraviolet (UV) light. This project focuses on overcoming the technical, economic and regulatory barriers to implementation by quantifying and advertising energy savings and pollution prevention capabilities.

PROCESS DATA: ONE BILLION CANS / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	25.2×10^9 Btu/yr	10.5×10^9 Btu/yr/unit	2.2×10^{12} Btu/yr
Environment (Waste Reduction)	2140 tons/yr	1050 tons/yr/unit	160,000 tons/yr
Economics (Payback)	---	4.7 years	---

TECHNICAL PERFORMANCE

UV-Curable Coatings for Aluminum Can Production

Background

The Coors Brewing Co. is a major, world-wide supplier of beer and related products. Coors produces over 12 million aluminum beverage cans / day in its Golden, Colorado plant. The focus of this project is the external surface printing and protective over-varnish curing process. Conventional technology uses solvent-based printing and over-varnish coatings that are applied to the aluminum and then cured (dried) by convective heat and mass transfer in gas-fired ovens.

Coors uses coating materials that cure when exposed to ultraviolet (UV) light. The problem is the industry-wide resistance to full implementation of the UV-curing technology. This project focuses on overcoming the technical, economic and regulatory barriers to implementation by quantifying and advertising energy savings and pollution prevention.

The goals of this project are: 1) to identify alternative, less-costly formulations of UV-curable coatings, including the consideration of economies achievable through a factor of a 25 fold increase in market size; 2) to confirm the energy savings and waste reductions achievable through full implementation of UV-curable system in the U.S. aluminum can manufactory industry; 3) to establish the regulatory status of the technology as a means for compliance with Clean Air Act provisions, including RACT, BACT, MACT and LEAR determinations; 4) to evaluate the cost-benefit impact of the technology on the industry; and 5) to encourage widespread recognition and acceptance of the technology through technical papers and presentations.

Technical Progress

All of the acrylate testing has been completed and documented. The optional testing of the cationic coatings will not be completed due to the following reasons: 1) RadTech, the UV trade association, is unable to assist, 2) project manpower shifts (the Coors project manager will be leaving the company in February), and 3) EPA would like to postpone the testing until later in 1996. A final report is being drafted and the project summary meeting will take place between late January to mid-February.

Technical Transfer

Coors is participating in this project to demonstrate its interest in preserving the environment, to reduce energy consumption and to encourage the regulatory acceptance of UV-curing as a

VOC control technology. The marketing plan includes: 1) demonstrating the benefits of the technology; 2) defining the improved economics that a greater market-share produces so that material and equipment suppliers can project the potential cost reductions; and 3) publish technical papers and present information to equipment manufacturers, industry groups and regulators.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual/ Revised
Conduct technology literature surveys	3/15/94	4/94
Confirm energy and cost savings	8/1/94	1/95
Confirm Pollution Prevention BenefitS	11/1/94	10/94
Product Quality Comparisons	4/1/95	ongoing
Seek recognition as a RACT, BACT, MACT or LAER technology	6/94-8/95	ongoing
Publish technical papers	6/30/95	ongoing
Conduct technical presentations	9/30/95	ongoing
Project Complete	9/30/95	1/30/96

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	50	250,000
State	3	12,908
Coors	47	237,092
Total	**100**	**500,000**

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*** POC for project description updates.**

NICE^3 PROJECT DATA

Full Body Powder Antichip Project

RECIPIENT:	Chrysler Corp.	**PROJECT NUMBER:**	94-DE-2
RECIPIENT PROJECT DIRECTOR:	Mary Snow-Cooper (302) 453-5273	**HQ PROGRAM MANAGER:**	Alan Schroeder (202) 586-1641
STATE:	Delaware	**GO PROJECT MANAGER:**	Doug Hooker (303) 275-4780
EPA / DOE REGION:	III	**LEAD STATE AGENCY:**	DE Dept. of Nat Res & Env. Control Andrea Farrell (302) 739-3822
CONGRESSIONAL DISTRICT:	DE (At Large)	**DOE SUPPORT OFFICE:**	Maryanne Daniel (215) 656-6964
CONGRESSIONAL REPRESENTATIVE:	Michael Castle(R)	**FISCAL YEAR AWARDED:**	1994
SENATORS: Joseph Biden, Jr. (D)	William Roth (R)		

PROJECT SCOPE: The proposed project will implement a powder painting unit to replace a solvent based operation that is the current industry standard. The result will be improved chip resistance and smoother paint surfaces. The proposed full body powder paint system would virtually eliminate VOC emissions and solid waste. In addition, the energy requirements for the proposed process are greatly reduced compared to the solvent-borne system.

PROCESS DATA: 80 FOOT POWDER PAINT BOOTH

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	56.7 x 10^9 Btu/yr/unit	3.4 x 10^9Btu/yr/unit	430 x 10^9 Btu/yr
Environment (Waste Reduction)	3,954 tons/yr/unit	249 tons/yr/unit	29640 tons/yr
Economics (Payback)	—	2.5 yr	-----

TECHNICAL PERFORMANCE

Full Body Powder Antichip Project

Background

Chipping is the major paint defect listed for customer dissatisfaction. The improved chip resistance and smoother paint surfaces produced by full body powder antichip will result in greater customer satisfaction and greater demand for U.S.-produced automobiles. The ability to compete with foreign automakers will strengthen the U.S. auto industry and result in more stable employment and job creation for U.S. workers.

At present, the coating industry standard for the application of antichip primer is a solvent-borne paint spray system. The solvent from the paint is either exhausted into the air or incinerated, while the particulate overspray is collected from a waterwash spray booth and landfilled.

The proposed full body powder antichip system is an innovative operation that would virtually eliminate volatile organic compound (VOC) emissions and solid waste. In addition, the energy requirements for the powder antichip system are greatly reduced as compared to the solvent-borne system due to the elimination of VOC incinerators, reduction of burners to warm booth air, and reduction of booth ventilation.

Although Chrysler has begun testing this process at another automobile manufacturing facility, it is an emerging technology, requiring continued development. The project will focus on the paint transfer efficiency (ratio of the paint solids deposited and the volume of the solids used), design of the powder spray booth, modification of oven ventilation, and development of automated equipment. The development of application equipment and processes during this full body powder antichip project will also be applicable to the future use of powder clearcoat.

Technical Progress

The powder paint application system was officially completed on July 31, 1995. Since then, the powder paint booth has been on-line in the Newark facility. The Full Body Powder Paint system has a 50 car/day capacity. Currently, the system is producing 34 cars/day because of reduced demand for Chrysler vehicles. Chryseler has quantified the energy, waste, and economic savings of the powder paint booth. The results of the study will be disclosed at the OIT conference in May.

Technical Transfer

Chrysler Corporation is a member of the United States Council for Automotive Research (U.S.C.A.R.), which is an organization that enables U.S. auto manufacturers to cooperatively develop pre-competitive technology that will enhance the long term competitiveness of its members. A Low Emission Powder Consortium (L.E.P.C.) has been created within the U.S.C.A.R. organization. Its initial objective is to develop the use of powder coatings in the automotive industry. This organization is a viable means of transferring powder antichip technology to interested parties in the automotive arena.

Commercialization: One unit in place.
Benefits: Aggregate energy savings: 26 billion Btu
Aggregate waste savings: 1850 tons paint sludge
Aggregate economic savings: $ 660,000

Milestones

Milestone	Planned	Actual/ Revised
Project Cost Estimates	3/17/94	10/94
Bids Requested	5/20/94	10/94
Bids Awarded	6/17/94	10/94
Construction Begins	7/8/94	10/94
Booth Construction Complete	8/31/94	5/95
Application Equipment Installation	9/1/94	6/95
Booth and Equipment Testing	1/2/95	7/95
Project completed - Production Ready	7/10/95	7/95

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	4	400,000
Chrysler	96	10,237,460
Total	**100**	**10,637,460**

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* POC for project description updates.

NICE^3 PROJECT DATA

Continuously Reform Electroless Nickel Plating Solutions

RECIPIENT: Ionsep Corp.

RECIPIENT PROJECT DIRECTOR: Sam Strobert (302) 798-7402

STATE: Delaware

EPA / DOE REGION: III

CONGRESSIONAL DISTRICT: DE (At Large)

CONGRESSIONAL REPRESENTATIVE: Michael Castle (R)

SENATORS: Joseph Biden, Jr. (D) William Roth (R)

PROJECT NUMBER: 94-DE-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: DE Dept. of Nat Res & Env Control
Andrea Farrell (302) 739-3822

DOE SUPPORT OFFICE: Maryanne Daniel (215) 656-6964

FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: This project will develop an elctrodialytic system that will reform and maintain hypophoshphite type electroless baths. The proposed modifications of the electroless nickel plating bath process will increase productivity through the elimination of down time for tank waste treatment and disposal and through the improvement of the plating by maintaining a consistent bath concentration. Energy consumption will decrease dramatically.

PROCESS DATA: 500 GALLON NICKEL PLATING BATH

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	710 x 10^6 Btu/yr/unit	600 x 10^6 Bty/yr/unit	687 x 10^9 Btu/yr
Environment (Waste Reduction)	51 tons/yr/unit	1.5 tons/yr/unit	51 x 10^3 tons/yr
Economics (Payback)	—	2.3 yr	—

TECHNICAL PERFORMANCE

Continuously Reform Electroless Nickel Plating Solutions

Background

Electroless nickel (EN) plating or auto catalytic nickel plating is the deposition of nickel alloys on a substrate through a chemical reaction on the substrate surface. The EN bath is an aqueous solution containing metal ions, a reducing agent, chelates, complexing agents and stabilizers. This process wets all surfaces of the substrate which creates a uniform thickness of the deposit. Applications of this type of plating are used in the following industries: automotive, aircraft, chemical equipment, railroad, electric motors, printing rolls, oil wells and mining, military, textile, electronics and material handling.

The nature of the electroless nickel plating process has the following characteristics: 1) the plating process consumes both reducing agent and metal causing material replenishment to maintain deposition; 2) the pH of the bath decreases from the H^+ by the plating process resulting in the addition of alkaline materials to maintain deposition; 3) the hydrogen gas produced decreases the efficiency of the plating process for nickel reduction; and 4) by-product ions accumulate in the bath. These results make reforming and recycling a challenging problem.

The goal of this project is to develop an electrodialytic system that will continuously reform and maintain hypophosphite type electroless nickel baths (90% of the market share). This reforming and maintaining of the electroless nickel plating bath will improve the overall process by increasing productivity through the elimination of down time for tank change out and through the improvement of the plating by maintaining a consistent bath concentration.

Technical Progress

An article in Environmental Engineering World has generated interest in the project. Several companies have volunteered to test the electrodialytic system. However, there are no plans for altering the current test site in Rochester, NY.

Construction of the commercial scale Ionsep Electroless Nickel System is under way. Projected delivery of the system is expected to be January 15,1995. The Eastman Kodak facility in Rochester, NY will be the first commercial installation of the regenerative nickel bath.

The new design will include multiple heat exchangers to minimize the possibility of thermal damage to the membranes. In addition to the heat exchanger design adaptation, Ionsep is attempting to find uses for the waste chemicals created by the regeneration system.

Technical Transfer

There are 500 electroless nickel plating shops in the U.S. and twice as many shops abroad. Because of the advantages, improvements, and savings realized in the areas of pollution prevention, manufacturing, energy, and resources, it is believed the economic and environmental incentives will encourage the proposed technology to be widely adopted in the U.S. and international markets. Information dissemination activities are currently not specific.

Commercialization: None to date. **Benefits:** None to date.

Milestones

Milestone	Planned	Actual/ Revised
Design Pilot Ectro-cell and System	4th Q 1994	4th Q 1994
Build and Manufacture Pilot Electro-cell and System	1st Q 1995	2nd Q 1995
Pilot Test Process with a test Plating Operation	2nd Q 1995	2nd Q 1995
Optimize Chemistry	3rd Q 1995	2nd Q 1995
Scale Up, Design, and Automate a Full Size System	4th Q 1995	
Build and Manufacture a Full Size Electro-cell and System	1st Q 1996	
Optimize the Full Scale System	2nd Q 1996	
Commercialize Use - Project Completed	3rd Q 1996	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	50	250,000
Ionsep	50	250,000
Total	100	500,000

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* POC for project description updates.

NICE^3 PROJECT DATA

Automated Dyebath Reuse in Carpet Manufacturing

RECIPIENT: Shaw Industries / GTRI

RECIPIENT PROJECT DIRECTOR: Jim Clarke / GTRI (404) 894-6103

STATE: Georgia

EPA / DOE REGION: IV

CONGRESSIONAL DISTRICT: GA-9

CONGRESSIONAL REPRESENTATIVE: Nathan Deal (R)

SENATORS: Sam Nunn (D) Paul Coverdell (R)

PROJECT NUMBER: 93-GA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Georgia Pollution Prevention Asst. Div.
Greg Andrews (404) 651-5120

DOE SUPPORT OFFICE: Tim Eastling (404) 347-7141

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: The current project proposes to demonstrate and evaluate a new analytical procedure for analysis, reconstitution and reuse of dyebaths in the dyeing of carpet in batch processes on a commercial scale. The project will investigate the automated process for dyebath reuse on both beck and jet drying machinery for carpets at a dyehouse. This demonstration is expected to lead to extensive adoption of dyebath reuse technology in carpet and other textile operations that practice batch dyeing.

PROCESS DATA: RECLAMATION OF 52 MILLION POUNDS OF DYEHOUSE WASTE

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	0.5×10^{12} Btu/yr/unit	2.9×10^{11}Btu//yr/unit	4.9×10^{12} Btu/yr
Environment (Waste Reduction)	1.2×10^{6} tons/yr/unit	1.4×10^{9} lb/yr/unit	50,000 tons/yr
Economics (Payback)	—	2.5 years	—

TECHNICAL PERFORMANCE

Automated Dyebath Reuse in Carpet Manufacturing

Background

The textile industry, a dominant element of the manufacturing sector in Georgia and the southeast, uses over 100 billion gallons of water annually. Much of this water is discharged from dyeing operations with appreciable quantities of dissolved and suspended organic and inorganic chemicals, some of which are potentially mutagenic, carcinogenic or difficult to remove colors and temperatures near 150° F.

Recent technology offers the potential for complete automation of reconstituting and reusing dyebaths in batch dyeing operations. The proposed program provides for development, demonstration and evaluation of a commercial scale, automated dyebath system in Shaw Industries carpet mill.

The current project proposes to demonstrate and evaluate this new analytical procedure for analysis, reconstitution and reuse of dyebaths in the dyeing of carpet in batch processes on a commercial scale. The project will investigate the automated process for dyebath reuse on both beck and jet dyeing machinery for carpets at a dyehouse owned and operated by Shaw Industries. This demonstration is expected to lead to extensive adoption of dyebath reuse technology in carpet and other textile operations that practice batch dyeing.

Technical Progress

Work on the dyebath reuse project addressed equipment needs for modification of Shaw's plant #2, developing the test plan for full-scale hot-start/hot-drop verification tests to be run at the Shaw plant during the first week of October (but interrupted by the hurricane), and development of further software for the analysis system. There have also been continuing tests to improve the confidence level in the performance of the dual-beam spectrometer.

Shaw conducted plant trials of hot-start and hot-drop dyeing of carpets to assess implications for product quality. These tests were similar to those conducted in June except (1) the recent tests were conducted on a full-sized dye beck, (2) a variety of shades and styles of carpets were tested, and (3) GTRI looked at a variety of hold times at various temperatures. The tests did not replicate the quality results that were seen last June. The less-satisfactory results may perhaps be attributed to the new chemistry system being less compatible with the hot-start/hot-drop or to the more challenging combination of styles and shades which were tested, or to the reduced hold times which were attempted in some of the tests. During follow-up tests with the new chemicals in the laboratory on campus, some difficulty was encountered in getting the chemicals into solution. This suggests some possible problem with the new chemistry system unrelated to our tests. In any event, it is not fully understood and investigations will continue.

Technical Transfer

The purpose of the proposed project is to transfer the automated dyebath reuse analysis system to full-scale, commercial carpet dyeing machine, specifically beck and jet dyers. After demonstration of the technology, the concept will be rapidly implemented first in the carpet batch dyeing sector, followed by the allied sectors across the textile sectors.

Commercialization: None to date. **Benefits:** None to date.

Milestones

Milestone	Planned	Actual/ Revised
Subcontracts let to other participating organizations	11/93	6/94
Baseline dye formulations selected	12/93	7/94
Dye formulations' compatibility with reuse established	4/94	9/94
Machine interface design completed	10/94	10/94
Control software development completed	1/95	12/94
Selection of hardware components completed	1/95	2/95
System installation completed	2/95	ongoing
Beck system demonstrations completed	7/95	
Jet system demonstration completed	9/95	
Update economic analysis completed	9/95	
Final report completed and submitted	10/95	
On-site workshop conducted for tech transfer	12/95	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	48	400,000
Georgia P2 Assistance Division	4	36,100
Georgia Research Alliance	20	167,340
Shaw Industries	15	125,000
Georgia Technology Research Institute	13	104,301
Total	**100**	**$832,741**

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NICE^3 PROJECT DATA

Advanced Mineral Calciner for Lime Regeneration in Pulp and Paper Manufacturing

RECIPIENT: Altex Technologies Corp., Weyerhaeuser

RECIPIENT PROJECT DIRECTOR: John Kelly (Altex) (408) 982-2300

STATE: Georgia

EPA / DOE REGION: IV

CONGRESSIONAL DISTRICT: GA-05

CONGRESSIONAL REPRESENTATIVE: John Lewis (D)

SENATORS: Sam Nunn (D) Paul Coverdell (R)

PROJECT NUMBER: 94-GA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: GA. Pollution Prevention Asst. Division
Greg Andrews (404) 651-5120

DOE SUPPORT OFFICE: Tim Eastling (404) 347-7141

FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: This project presents a superior technology for recovering lime from spent lime waste generated by the pulp and paper industry. The approach is meant to be an alternative to the currently used rotary kilns that are very inefficient in terms of maintenance, quality of the recovered lime, energy costs and NOx emissions. The presented process will provide the industry with a superior technology that will allow for more efficiency in energy consumption and process operation, recovery, and re-use of most lime waste.

PROCESS DATA: 160,000 TONS OF REGENERATED LIME / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	1.16 x 10^{12} Btu/yr/unit	0.76 x 10^6 Btu/yr/unit	15 x 10^{12} Btu/yr
Environment (Waste Reduction)	206,000 tons/yr/unit	80,000 tons/yr/unit	3.7 x 10^6 tons/yr
Economics (Payback)	—	5 yr	—

TECHNICAL PERFORMANCE

Advanced Mineral Calciner for Lime Regeneration in Pulp and Paper Manufacturing

Background

There are approximately 800 pulp, paper, and paperboard mills in the United States. Pulp and paper is the ninth largest industry in the country. The pulp and paper industry uses 2.8 quads of energy per year and ranks third among all domestic U.S. industries in the cost of energy consumed. A significant fraction of the energy consumed in pulp and paper plants is needed to recover chemicals that are used in breaking down the wood chips into pulp. In particular, 0.1 quads of energy per year are used to regenerate lime.

In pulp and paper manufacturing, lime is used to recover the sodium hydroxide needed to delignify wood chips to form pulp. In the chemical recovery process, the lime is converted into a precipitated calcium carbonate mud that contains approximately 25 percent moisture. Typically a high temperature rotary kiln is then used to dissociate, or calcine, the mud back into lime for recycle into the process loop. By regenerating the lime, spentlime-waste disposal and fresh lime chemical costs are minimized.

The Advanced Mineral Calciner (AMC) system, identified by Altex, is more compact, simpler, lower in cost, more energy efficient, and lower in NOx emissions and spent-lime-waste production than conventional kilns. The goal of the project is to show, through small-scale testing, the feasibility of implementing the Advanced Mineral Calciner (AMC) using commercially available equipment. If this can be shown, then no major equipment development efforts would be needed and the AMC could rapidly progress towards large-scale demonstration and commercialization.

Technical Progress

The Advanced Mineral Calciner processing equipment design and buildup continued at Altex. The lime mud conveying and handling equipment for a continuous extrusion process is complete. Altex will add a dryer to the system to dehydrate the pellets prior to storage. Test runs on the AMC prototype system have shown the viability of the continuous lime mud generation process.

Work continued on upgrading the existing shaft kiln for AMC testing. Design work continued on upgrading fuel, air, and exhaust systems, to better simulate the AMC Multiple Vertical Column shaft kiln.

The DOE GFO project monitor and Georgia state contract administrators conducted a site visit in December, 1995. Altex has produced a video tape of the process. This tape will be used to market the AMC to paper plants throughout the nation.

Technical Transfer

After the test results are in, Altex, equipment suppliers, Weyerhaeuser and the Industrial Gas Technology Commercialization Center will meet to discuss the benefits of the AMC over the existing kiln technology. Once AMC performance, operation and costs are shown to be favorable, the plant will be turned over to Weyerhaeuser to be used in a production mode. Simultaneously, KVS, a kiln supplier, will initiate a series of steps to notify industry of the availability of the new technology through meetings, announcement, and plant site visits.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual
Complete Lime Mud Pretreatment Tests	1/30/95	6/95
Complete Lime Mud Processing Tests	6/30/95	8/95
Complete Technical and Cost Evaluations	8/30/95	
Project complete	9/30/95	

Budget & Cost Sharing

Funding Source	Amount, $	Amount, $
DOE / EPA	47	408,033
Altex, et al.	53	456,700
Total	100	863,733

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NICE³ PROJECT DATA

Recovery and Reuse of Water-Washed Overspray Paint

RECIPIENT: Caterpillar Corp.

RECIPIENT PROJECT DIRECTOR: George M. Mitchell (309) 675-3887

STATE: Illinois

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: Il -18

CONGRESSIONAL REPRESENTATIVE: Ray LaHood (R)

SENATORS: Carol Moseley-Braun (D) Paul Simon (R)

PROJECT NUMBER: 94-Il-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Il. Dept. of Commerce and Community Affairs
Andrea Schmidt (217) 785-0164

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: This project will demonstrate the commercial viability of a Caterpillar developed Spangler process that recaptures and reuses a previously landfilled paint sludge from water-wash paint operations. Approximately half of all paint purchased for many spray operations is oversprayed, wasted, and in almost all cases, landfilled in one form or another. The Spangler process is more energy and cost efficient than past practice and will produce product coatings that meet or exceed engineering specifications.

PROCESS DATA: RECLAMATION OF 110 TONS OF PIGMENT

E³	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	5.2×10^9 Btu/yr/unit	1.61×10^9 Btu/yr/unit	119×10^9 Btu/yr
Environment (Waste Reduction)	1250 tons/yr/unit	0	41,250 tons/yr
Economics (Payback)	—	2.5 yr	—

TECHNICAL PERFORMANCE

Recovery and Reuse of Water-Washed Overspray Paint

Background

Depending on the type of gun technology used for a given spray operation, transfer efficiency (the percentage of paint sprayed which actually adheres to the item being painted) will typically range from 30-70%. That reality translates into approximately half of all paint purchased for many spray operations being oversprayed, wasted, and in almost all cases, landfilled in one form or another. The water-wash overspray collected at the East Peoria plant alone, approximately 500,000 lbs. annually, requires an expenditure of $149,000 when conventionally treated and landfilled. A typical automotive assembly plant in an average year generates and landfills approximately 2.5 million pounds of

Burial disposal of this paint material has been necessary primarily because no cost effective recycling alternatives have been available. Efforts to resolve the problem have generally been unsuccessful; that is, until now. By development and full scale implementation of the Spangler (proposed) process at the Caterpillar East Peoria plant, and through successful external funding efforts of the Paint Waste Resource Team (PWRT), it will be proven economically and technically feasible to recover oversprayed paint, chemically and physically process it, and reuse the reclaimed material in the new high performance coatings used in the manufacture of Caterpillar products.

The purpose of this project is to demonstrate the commercial viability of the Caterpillar developed Spangler process that recaptures and reuses landfilled industrial water-wash paint sludge. To date the method to fully detackify overspray paint waste without destructively altering its composition and the development of a consistent process for reclaiming and recycling this raw material into new paint for production of Caterpillar products have been completed at the pilot scale level. Escalation from pilot to full production scale is the next logical step for expansion of the Spangler process.

Technical Progress

The processing room was stripped, cleaned, and painted (with recycled paint). Footings for the tank supports were poured and the processing tanks were installed. Caterpillar engineers integrated the tanks and have begun to debug the process.

In January, Caterpillar will begin processing the paint material that they have accumulated over the past three years. The NICE^3 project won the Caterpillar 1995 Pollution Prevention corporate (worldwide) award.

Technical Transfer

The marketing approach involves developing as many markets internal to Caterpillar as possible. It has already been addressed that Caterpillar intends to reuse reclaimed pigment on its products, however additional market penetration will be achieved by demonstrating the performance of the product in internally utilized maintenance paint coatings. As a large consumer of such coatings, Caterpillar has sizable leverage when dealing with suppliers.

To reach the greatest possible audience of coatings manufacturers and consumers, Caterpillar plans to promote the technology by demonstrating the process and its success at paint industry trade shows. Two major shows, PaintCon and SprayCoat, occur annually and present the latest in technology innovation to thousands of large and small users of coating products. NICE^3 funds will be used to defray the considerable cost of presentation at these gatherings. That combined with publication in industry journals and tours of the completed Caterpillar facility will help to bridge the gap between industries, users, and the companies that supply their coating products.

Commercialization: None to date.

Benefits: None to date.

Milestones

Milestone	Planned	Actual/ Revised
Verify Proposed System	4th Q 1994	4th Q 1994
Prepare Specifications for System Operation	4th Q 1994	1st Q 1995
Partnership with Coating Suppliers	3rd Q 1995	2nd Q 1995
Install Reclamation System	3rd Q 1995	
Promote Recycling System	4th Q 1996	
Demonstrate Application at Conferences	1st Q 1996	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	36	284,500
Caterpillar	64	504,500
Total	100	789,000

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* POC for project description updates.

NICE^3 PROJECT DATA

Electrophotographic Screening: Color Picture Tube Production

RECIPIENT: Thomson Consumer Electronics

RECIPIENT PROJECT DIRECTOR: Randy Strutz (317) 662-5375

STATE: Indiana

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: IN-5

CONGRESSIONAL REPRESENTATIVE: Steve Buyer (R)

SENATORS: Richard Lugaar (R) Dan Coats (R)

PROJECT NUMBER: 93-IN-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Indiana Dept. of Commerce, Energy Policy, Dan Mirkler, (317) 232-8961

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: The Electrophotographic Screening (EPS) process has two major advantages in the production of color picture tubes: 1) it will reduce energy consumption, and 2) it will reduce waste in the form of phosphor. A major advantage of EPS is that it can be utilized as both a low cost process and a high tech advanced product manufacturing process. EPS represents a new basic technology for the entire industry and is positioned to become the screening technology of the next century.

PROCESS DATA: ONE EPS MODULE

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	363×10^9 Btu/yr/unit	86×10^9 Btu/yr/unit	1.93×10^{12} Btu/yr
Environment (Waste Reduction)	967×10^3 tons/yr/unit	40×10^3 tons/yr/unit	6.77×10^6 tons/yr
Economics (Payback)	—	4.9 years	—

TECHNICAL PERFORMANCE

Electrophotographic Screening: Color Picture Tube Production

Background

Thomson Consumer Electronics is one of the top ten employers in Indiana manufacturing colored picture tubes ranging in size from 19 to 35 inches. The Marion plant has the distinction of having produced more picture tubes than any other plant in the world. Current production processes employ many steps ranging from heat drying to phosphor reclamation. A newly patented process of Electrophotographic Screening (EPS) will eliminate the majority of these steps resulting in a reduction of energy consumption and hazardous waste by-products, which in turn will reduce chemical requirements.

The EPS process has two major advantages: 1) it will reduce energy consumption, and 2) will reduce waste in the form of phosphor. EPS involves putting on and taking off phosphor from picture tubes and is a guarded trade secret. EPS has been under development for the past six years and it is estimated that the initial pilot project will be for three years.

EPS represents a new basic technology for the entire industry and is positioned to become the screening technology of the next century.

Technical Progress

Organic Photoconductive panels were processed at the Lancaster research facility. Lancaster personnel returned to the Marion production facility to upgrade the EPS production modules and to resolve the problems with the Optical Photoconductor (OPC) electrostatic spray.

Tubes are being processed on a weekly basis to monitor tube quality. Blue and green uniformity on the majority of tubes is of commercial quality. The red continues to experience fixing problems. The consistency of the phosphorus deposition was greatly improved. Registry and line definition are excellent. However, contamination problems continue. The Fixing/Filming process is the focus of the debugging effort. The OPC spot type defects have become a chronic problem during the past few weeks.

Technical Transfer

After proving the EPS concept, Thomson plans to carry out the following with regard to marketing/commercialization:

1) Demonstrate the process to other manufacturers.
2) Show potential benefits of reduced energy cost, lower waste/pollution costs, process control improvement, lower labor cost, increased factory space utilization and wider phosphor selection.
3) Potential for licensing revenues on process and/or equipment would allow for more rapid payback of initial investment.

Commercialization: None to date.

Benefits: None to date.

Milestones

Milestone	Planned	Actual/ Revised
Design-Build-Install Prototype	9/28/93	12/94
Transfer Equipment	9/28/93	12/94
Prototype Process Modules	5/30/94	11/94
Process Development	5/4/94	12/94
Area Prep	12/31/94	11/94
Process Debug / Testing	3/15/95	4/95
Evaluate Manufacturing Capability	8/30/95	
Transfer to Full-scale Production	8/30/95	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	40	400,000
State	20	200,000
Industry	40	400,000
Total	**100**	**1,000,000**

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* POC for project description updates.

NICE^3 PROJECT DATA

OXY-FUEL BURNERS FOR STEEL REHEATING

RECIPIENT: Bethlehem Steel Corp.
RECIPIENT PROJECT DIRECTOR: Norman Hodgson (219) 787-3341
STATE: Indiana
EPA / DOE REGION: X
CONGRESSIONAL DISTRICT: IN-1
CONGRESSIONAL REPRESENTATIVE: Peter Visclosky (D)
SENATORS: Richard Lugar (R) Dan Coats (R)

PROJECT NUMBER: 95-IN-1
HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641
GO PROJECT MANAGER: Doug Hooker (303) 275-4780
LEAD STATE AGENCY: IN Dept. of Commerce, Energy Div. Dan Mirkler (317) 232-8961
DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571
FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Steel reheating is an energy-intensive process that requires uniform temperature distribution within the furnace. The goal of the proposed program is to demonstrate the economic, environmental, and quality benefits of an advanced oxyfuel fired combustion system for a continuous slab reheat furnace. The oxy-fuel combustion system reduces furnace rebuild costs, fuel consumption, and emissions of NOx, SOx, CO_2, and CO. Productivity, yield, and product quality benefits are also anticipated.

PROCESS DATA: ONE FURNACE

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	470 X 10^9 Btu/yr	320 x 10^9 Btu/yr	4.23 x 10^{13} Btu/yr
Environment (Waste Reduction)	28,450 tons/year	21,567 tons/year	623 x 10^3 tons/yr
Economics (Payback)	---	3 yrs	—

TECHNICAL PERFORMANCE

OXY-FUEL BURNERS FOR STEEL REHEATING

Background

Steel reheating is an energy-intensive process that requires uniform temperature distribution within the furnace. Historically, energy conservation has been achieved by installing recuperators to preheat combustion air. Oxygen enrichment has also been used. Conventional 100% oxygen-fuel burners, which would reduce energy consumption significantly, have not been used. More recent innovations have included regenerative burners, which provide higher air preheat temperatures than recuperators. All of these processes have limitations such as deterioration with time, decreasing energy-efficiency over time, high maintenance costs, and the addition of NOx emissions with increased air preheat temperature, unless special equipment is used. Oxy-fuel burners which use 100% oxygen without these inherent problems of conventional oxy-fuel burners are the key component of the combustion system to be demonstrated.

Although such burners were successfully demonstrated in steel reheat furnaces in the 1980's, commercial installation in continuous reheat furnaces did not result due to changes in economic and business conditions. In all demonstrations, fuel savings and uniform temperature distribution were achieved. Oxy-fuel combustion has not been demonstrated in continuous slab reheat furnaces which are used to produce sheet and plate, by far the largest product segment of the steel industry. The technology is currently being used in the glass, hazardous waste, and aluminum industries.

The technical goal of the project is to successfully demonstrate the use of oxy-fuel burners in a slab reheat furnace, to reduce energy consumption by 45% and NOx emissions by 90% for the converted furnace zones. This will also eliminate the need to replace or rebuild the recuperator or install NOx removal equipment. Oxy-fuel combustion reduces or eliminates nitrogen in combustion air and substantially reduces waste heat carried out with the flue gas. Praxair, Inc. (formerly the Linde Division of Union Carbide Industrial Gases, Inc.) has developed and patented low flame temperature oxy-fuel burners that can be used in high temperature industrial furnaces where temperature uniformity is critical.

Technical Progress

Contract: Contract/grant negotiations are ongoing. This is an FY 1995 award.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

Praxair intends to market this technology first to its existing customer base which represents about 50% of the integrated and 40% of the EAF market segments. It should also be noted that Praxair currently has installed or contracted for all nine of the VPSA systems currently supplying the EAF market segment, and this trend should continue. Praxair currently has fourteen engineers who develop and implement application technology for the steel industry. This group, combined with resources from our partner, North American Manufacturing, and our respective sales organizations, are available to rapidly market and implement this technology on a global basis. North American Manufacturing would also market the technology to the remaining producers who are not Praxair customers. Marketing efforts have already been initiated through two presentations at major industry meetings. Once a successful demonstration project has been completed, future marketing efforts would be carried out jointly by Praxair and North American and include:

1. Continued promotion at industry meetings and trade shows.
2. Visits to targeted high priority customers.
3. Carry out detailed furnace analyses to estimate benefits.
4. Provide complete retrofit package including equipment, 0_2 supply, start-up, training, etc.

Milestones

Milestone	Planned	Actual / Revised
System Engineering	1/96	
Equipment Manufacture	5/96	
Oxygen Pipeline Installation	5/96	
Base Performance Data	6/96	
Installation & Start-Up	7/96	
Performance Demonstration	8/96	
Final Report	11/96	
Project Complete	12/96	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	39	425,000
State	7	75,000
Industry	54	578,729
Total	100	1,078,729

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* POC for project description updates.

NICE^3 PROJECT DATA

The Manufacture of Tissue Paper Products Using High-Content Post-Consumer Waste

RECIPIENT: Erving Paper Mill
RECIPIENT PROJECT DIRECTOR: Paul Sullivan (508) 544-2711
STATE: Massachusetts
EPA / DOE REGION: 1
CONGRESSIONAL DISTRICT: MA-01
CONGRESSIONAL REPRESENTATIVE: John Olver (D)
SENATORS: Edward Kennedy (D) John Kerry (R)

PROJECT NUMBER: 94-MA-1
HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641
GO PROJECT MANAGER: Doug Hooker (303) 275-4780
LEAD STATE AGENCY: MA Division of Energy Resources
Dan Sardo (617) 727-4732
DOE SUPPORT OFFICE: Robert Allen (617) 565-9715
FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: Erving Paper Mills (EPM) will modernize their process line by using technology and chemistry not previously combined in the paper making industry. In-line particle analyzers will be installed to allow real time adjustment of the amount of post-consumer pulp added during the process. The "Nucell Process which involves both mechanical and chemical changes to the paper pulping, washing, de-inking, and blending will be installed. Current chlorine based bleaches will be replaced with newly developed substitutes.

PROCESS DATA: 52,000 TONS OF PAPER PRODUCED

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	8.81 x 10^{11} BTU/yr/unit	6.45 x 10^{11} BTU/yr/unit	13.3 x 10^{12} Btu/yr
Environment (Waste Reduction)	2.9 x 10^{6} tons /yr/unit	2.88 x 10^{6} tons/yr/unit	1.4 x 10^{6} tons/yr
Economics (Payback)	—	6.1 yr	—

TECHNICAL PERFORMANCE

The Manufacture of Tissue Paper Products Using High-Content Post-Consumer Waste

An increase in the quantity of post-consumer waste paper in the paper also increases the amount of dirt, ink particles and other impurities. This gives the paper a gray appearance, often with visible dirt particles. These characteristics are not acceptable for many paper uses, necessitating the use of de-colorants or bleaches. A number of chlorinated compounds are generated in the paper making process as the result of the use of chlorine compound bleaches to whiten paper pulps. This project will enable more use of post-consumer pulps while eliminating the use of chlorine compound bleaches by Erving Paper Mills, EPM. In addition, EPM has found a way to eliminate 80% of their paper waste, while developing a saleable byproduct that can be used to cap landfills at approximately one-third the present cost.

A thorough modernization of the process line is proposed, using technology and chemistry not previously combined in the paper making industry. The changes will enable EPM to successfully increase the amount of post-consumer waste paper in their product without decreasing the quality (and value) of the product. One change involves the installation of in-line particle analyzers, allowing real-time adjustment of the amount of de-inked, post-consumer paper pulp added during the process, increasing the percentage of post-consumer pulp in the mixture to the highest level possible consistent with the desired grade of paper. It will also prevent rolls being scrapped or downgraded because of higher than allowable particle content.

The second element, called the "Nucell Process" by EPM, involves both mechanical and chemical changes to the entire process of paper pulping, washing, de-inking, and blending. The third element is the replacement of current chlorine-based bleaches with newly-developed substitutes called FAS and Enessco-D.

Technical Progress

Erving paper continues to have major difficulties with the particle analyzers. Irregular flow across the sensors are causing the control system to display erroneous particle density measurements. Kelvin, the particle analyzer manufacturer, is apparently trying to sell the Flow Vision part of the business. E.P.M does not have access to any more information at this time.

Construction of the thick stock storage chest is beginning. The anticipated completion is May 1996. This chest will allow Erving Paper to test alternative brightening chemicals such as FAS. Erving paper is considering restarting the Enessco-D trials; the price of the chemical has steadily declined due to domestic production increases.

Technical Transfer

EPM is committed to sharing the results of the project with non-competing sectors of the paper making industry immediately, via articles in trade publications and environmental journals plus technology transfer via on-site visits by OTA to other Massachusetts companies. Because vendors are using EPM for beta-site testing, they are anxious to capitalize on the new market potential of this innovative system. Marketing strategies are listed below:

1) Direct technology sharing will be initiated with other paper mills via publication of project results in TAPPI Journal, Pulp & Paper, American Papermaker and other industry trade journals; 2) Project vendors will be encouraged to discuss the new system with their customers in the paper industry; 3) Let customers know that EPM has made a significant new "green" contribution to the industry and deserves their support. Use similar articles in leading environmental publications such as "E" (the environmental magazine)" and "Garbage;" 4) Submit the project summary to MA Office of Technical Assistance and a Case Study to EPA's Technology Transfer Network (TTN) bulletin board; and 5) Arrange for tours of the EPM facility by interested professionals from the paper, energy, and environmental arenas.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual
Particle Analyzer Trials	9/94 - 11/94	4/95
Chemical Trials	9/94-1/95	4/95
Solids for FiberClay Transfer Pipeline	10/94-2/95	5/95
Particle Analyzer on Line F/T	3/95	
Chemical Hand. Equip. Installed / On Line	5/95 - 8/95	
Washer Installation	8/95	
FiberClay Handling Equip. Installed	9/95	
Washer - On Line	10/95	
FiberClay Equip. - On Line	1/96	
Finished Prod. Hand. Equip. Installed / On Line	3/96 - 5/96	
Project Evaluation / Final Report	6/96 - 12/96	

Budget & Cost Sharing

Funding Source	%	Amount
DOE / EPA	16	425,000
State	1	10,371
Mass Electric	15	400,000
Erving Paper	68	1,900,000
Total	**100**	**2,735,371**

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* POC for project description updates.

NICE^3 PROJECT DATA

Solid State Radio Frequency Electrodeless Light Source

RECIPIENT: Westinghouse Corp. & Fusion Systems

RECIPIENT PROJECT DIRECTOR: Ray Smith (410) 765-3843

STATE: Maryland

EPA / DOE REGION: III

CONGRESSIONAL DISTRICT: MD-05

CONGRESSIONAL REPRESENTATIVE: Steny Hoyer (D)

SENATORS: Paul Sarbanes (D) Barbara Mikulski (D)

PROJECT NUMBER: 93-GA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Maryland Energy Administration
Charles L. Miller Jr. (410) 974-2190

DOE SUPPORT OFFICE: Maryanne Daniel (215) 656-6964

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: Fusion has developed an innovative light source which offers exceptional efficiency and very long life. Westinghouse and Fusion lighting are proposing a project to develop a solid-state RF power source. The present state-of-the-art for electrodeless lamps involves the use of a magnetron, similar to that used in a microwave oven. This project will develop an efficient, compact, highly efficient and inexpensive radio frequency (RF) source to couple to the lamp.

PROCESS DATA: 14 MILLION LUMEN FACILITY

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	389,000 Btu/yr/unit	210,600 Btu/yr/unit	690 x 10^{12} Btu/yr
Environment (Waste Reduction)	1695 tons/yr	440 tons/yr	108 x 10^{6} tons/yr
Economics (Payback)	—	1.7 yrs.	—

TECHNICAL PERFORMANCE

Solid State Radio Frequency Electrodeless Light Source

Background

Various lamps that provide visible illumination are well known. These include incandescent, fluorescent, neon, mercury vapor, sodium vapor and other more exotic sources. Another category of lamps depend upon radio frequency (RF) or microwave radiation to excite a gaseous vapor contained within a glass or quartz bulb to generate light. These are known as "electrodeless" lamps. The Fusion Systems Corporation pioneered the industrial use of high-powered electrodeless microwave discharge lamps for generating ultraviolet energy. Recently, the discovery of a unique plasma system has enabled the extension of this technology to the production of visible lighting systems with outstanding performance.

The present state-of-the-art for electrodeless lamps involves the use of a magnetron, similar to that used in the common microwave oven. This involves a relatively complex housing to shield the microwave energy while allowing the light to be emitted. This system does not lend itself readily to commercialization and widespread use of the new visible lighting system. An efficient, compact, highly efficient and inexpensive radio frequency power source needs to be developed and coupled to the new lamps.

The goal of this project is to evolve a high efficiency, compact, solid-state radio frequency power source for driving the new visible lamps. The program would include, but not necessarily be limited to:

- Investigation of frequency effects (microwave and lower frequencies).
- Investigation of coupling techniques to efficiently direct the energy into the lamp.
- Develop a practical solid state power amplifier/source and compatible package for integration with the lamp.
- Design, fabricate and test prototype hardware.

Technical Progress

A site visit was conducted by DOE reviewers. Fusion Lighting is preparing bulbs designed to receive 100 watts RF from the Westinghouse power source. Old Fusion Lighting bulbs were tested with the RF source breadboard at Westinghouse. The transfer efficiency of the system was rated at 65%. The efficiency will increase when the Fusion Lighting supplies the final coupling system and the proper bulbs.

Westinghouse has completely assembled the new package containing the frequency source, power amplifier, and matching circuit. The interface between the coupling coil and the bulb will be completed as soon as the coil configuration is finalized by Fusion Lighting. Currently, Fusion Lighting is using computer modeling to simulate power transfer between the induction coil and the bulb.

Technical Transfer

The technological factors required to provide visible electrodeless lighting are presently in the demonstration stage. Fusion Lighting has developed a series of high intensity, highly stable bulbs and have peaked the interest of many potential customers and agencies (eg. DOE, NASA, EPA, and the National Air & Space Museum). Several demonstration customers have already been identified in the U.S. and abroad. As this technology is proven to be successful, negotiation with the large bulb manufacturers (Phillips, GE, Sylvania, etc...) will take place to license this technology to the marketplace.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual / Revised
RF Coupling Experiments	11/94	2/95
RF Source Development	2/95	4/95
Production Device Analysis	5/95	
Packaging Design	3/95	
Fabricate Amplifier Model	4/95	
Integrate Amplifier & Lamp	5/95	
Test	7/95	
Final Report	8/95	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	44	399,398
Industry	56	510,000
Total	100	909,398

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* POC for project description updates.

NICE^3 PROJECT DATA

An Innovative Process to Deice Airplanes

RECIPIENT: CCSI, Inc.

RECIPIENT PROJECT DIRECTOR: John Gaughan (410) 569-1200

STATE: Maryland

DOE REGION: III

CONGRESSIONAL DISTRICT: MD-2

CONGRESSIONAL REPRESENTATIVE: Robert L. Ehrlich (R)

SENATORS: Barbara A Mikulski (D) Paul S. Sarbanes (D)

PROJECT NUMBER: 95-MD-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Maryland Energy Administration
Charles Miller (410) 974-2190

DOE SUPPORT OFFICE: Maryanne Daniel (215) 656-6964

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: CCSI will demonstrate a multi-purpose mobile unit which provides rapid, efficient aircraft deicing and anti-icing in a single pass as an aircraft taxis through the device just prior to take-off. The patented system uses heat, compressed air to remove snow and ice; immediately followed by a precise application of anti-icing fluids to prevent the wings from re-freezing. Field tests show reduced glycol usage by 60-70% with 95+% of excess chemicals recovered for reuse. Process time would be reduced by 80%.

PROCESS DATA: ONE DEICING SYSTEM

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	233 x 10^9 Btu/yr/unit	2.2 x 10^9 Btu/yr/unit	57.9 x 10^{12} Btu/yr
Environment (Waste Reduction)	130,000 tons/yr/unit	52,983 tons/yr/unit	19.4 x 10^6 tons/yr
Economics (Payback)	- - -	1.45	- - -

TECHNICAL PERFORMANCE

An Innovative Process to Deice Airplanes

Background

The deicing of airplanes has always been an important aviation industry challenge, because even a small amount of ice on the wings can seriously impair an aircraft's ability to take off. These dangers have been officially recognized by regulation as early as 1950 by the Civil Aeronautics Board and remain in effect today under Federal Aviation regulations. For almost forty years, the airline industry has responded to the problem of deicing airplanes in the same way, by spraying glycol onto the plane by hoses mounted on trucks. The spraying is done in two steps: once to remove the snow and ice and a second time to prevent the buildup on wing surfaces.

The theoretical basis of the proposed "Whisper Wash™" technology is that the thermodynamic and kinetic energy requirements of a deicing system (in this case a wing coated with ice) can be defined with equations that are independent of medium (i.e. liquid, gas, or solid) that is used to transfer the heat to the wing. These equations also show that the amount of heat and "push" can be easily quantified and the amounts are significantly lower than the current technology.

The "Whisper Wash™" system consists of two flat-bed trailers onto which adjustable horizontal boom arms are attached. This provides a portable, profile adjustable structure (roughly analogous to a car wash) which an aircraft of any size can taxi through for treatment while on route to the take-off runway. The boom arms are outfitted with two sets of proprietary nozzles. One set is pneumatic, for the delivery of heated compressed air for deicing. The other set of nozzles are hydraulic, for the delivery of precise amounts of glycol for anti-icing. Both steps take place in a single "pass".

The "Whisper Wash™" unit is placed as close as possible to the end of the departure runway to minimize the time between treatment and take-off. This is a significant improvement over current logistics in which aircraft are primarily deiced/anti-iced at the departure gate. In many airports the taxi time from the gate to the runway can exceed the safety margins for ice build-up (i.e. holdover time) and force a plane to return for treatment.

Technical Progress / Project Status

Design for the deicing system has been completed by Ammand and Whitney, Inc. In addition to the design, the consulting engineering company set parameters for flow rates using small-scale modeling. The location for the final test has been established at the Baltimore-Washington International Airport (end of runway 15R).

Commercialization: None to date.
Benefits: None to date.

Technical Transfer

In order to prove the technology at a commercial level, a full-scale, 40-foot section with all of the full scale nozzles, pumps, and compressors, and controls to demonstrate the flow rates and snow/ice removal capacity of the design will be constructed. The demo unit will serve to overcome two impediments that have prevented commercialization to date: 1) safety: the unit will show improved snow/ice removal and holdover time which will allow the system to become "Best Available Technology" driving industry acceptance, and 2) benefits: the unit will verify glycol consumption rates, throughput capacity, and economic benefits.

The transfer of technology to a national level will be accomplished via licensing and franchise contracts with fixed based operators who already provide fueling and support services to major and regional air carriers. Initially, 30 of the major U.S. airports will be targeted because they have already been cited or fined by the EPA or identified by the FAA as requiring end-of-runway deicing. Initial orders for 7 units are anticipated on the basis of current marketing efforts and correspondence.

Milestones

Milestone	Planned	Actual / Revised
Complete drawings - order materials	11/95	11/95
Receive materials and prepare test site	12/95	12/95
Complete assembly and install at site	2/96	
Begin testing on static wing	3/96	
Complete field tests on moving aircraft	4/96	
Prepare final report	5/96	
Project complete	6/96	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	50	405,000
State	0	0
Industry	50	405,000
Total	**100**	**810,000**

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* POC for project description updates.

NICE^3 PROJECT DATA

Bioconversion of Low Value Molasses By-product to High Value Organic Acid Phytochelates (Fertilizer Enhancement)

RECIPIENT: Michigan Biotechnology Institute

RECIPIENT PROJECT DIRECTOR: Bob Coleman (517) 336-4668

STATE: Michigan

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: MI-8

CONGRESSIONAL REPRESENTATIVE: Dick Chrysler (D)

SENATORS: Spence Abraham (R) Carl Levin (D)

PROJECT NUMBER: 93-MI-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Michigan Public Service Company
John Trieloff (517) 334-7233

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: Bioconversion of low value by-products from sugarcane will be used as a source of organic acids which can add value to fertilizers by acting as chelating agents (phytochelates) increasing the availability of metal nutrients to plant tissue. The project will 1) develop a cost-effective chromatographic separation of sucrose from molasses; 2) produce and recover organic acids from the chromatographic raffinate stream; and 3) test the organic acids as phytochelates in various environments.

PROCESS DATA: BIOSTIMULANTS EQUIVALENT TO 640 MILLION TONS OF UREA

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	1.2 x 10^{12} Btu/unit/yr	654x 10^{9} BTU/unit/yr	1.3 x 10^{13} Btu/yr
Environment (Waste Reduction)	388,706 tons/unit/yr	64,236 tons/unit/yr	3.2x10^{6} tons/yr
Economics (Payback)	—	2.5 years	—

TECHNICAL PERFORMANCE

Bioconversion of Low Value Molasses By-product to High Value Organic Acid Phytochelates (Fertilizer Enhancement)

Background

Environmental problems associated with overuse of N fertilizers have been well documented. In consequence, limitations on fertilizer use have been imposed in several countries. Moreover, fertilization of forest biomass was recently identified as the, most cost-efficient option of mitigating global warming. The increased use of fertilizers to address problems of food availability and global warming will lead to increased N pollution of the environment.

A major goal of this proposal is to develop a method to increase fertilizer efficiency. Bioconversion of low value by-products from sugarcane will be used as a source of organic acids which can add value to fertilizers by acting as chelating agents (phytochelates) and increasing the availability of metal nutrients to plant tissue.

The project will 1) develop a cost-effective chromatographic separation of sucrose from cane molasses; 2) produce and recover succinic and lactic acids from the chromatographic raffinate stream; and 3) test the organic acids as phytochelates in controlled laboratory, greenhouse studies, and field trials.

Technical Progress

MBI has submitted a statistical analysis of the cherry tree trial results to the DOE. Low nitrogen trees receiving a biostimulant formulation outperformed all untreated, low, medium, and high nitrogen trees by substantial margins. Hence, it appears that low amounts of nitrogen could be used together with the biostimulant to increase yields in commercial crops.

MBI and Michigan State University have started field trials on Scotch pine and Douglas fur. Using the same formulation (#4) that was successful in the cherry tree trails, MSU researchers will apply the biostimulants on the surface area of the evergreens.

Technical Transfer

The project collaboration provides the correct balance of technical, marketing and business expertise. Communication and periodic technical and marketing reviews will be encouraged, including invitation of sponsors and potential project participants to MBI's reviews. The project is heavily oriented toward achieving industrial participation for all phases of the project. Several groups looking for high value products derived from food by-products have contacted MBI with regard to phytochelate technology. Grand River Technologies, a for profit subsidiary of MBI, has been formed to facilitate the commercialization of the proposed technology.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual/ Revised
Obtain, test and store appropriate acid producing strains	3rd Q, 1993	3rd Q 1994
Complete analysis of phytochelate activities	4th Q, 1993	10/94
Develop fermentation medium to supplement sugar syrups	1st Q, 1994	1/95
Complete analysis of phytochelate activities using dilute fermentation	2nd Q, 1994	3/95
Develop recommendations for process modifications	3rd Q, 1994	4/95
Conduct workshops to review progress	4th Q, 1994	
Repeat fermentation and recovery with process modifications	1st Q, 1995	5/95
Analyze phytochelate activities on target crops	2nd Q, 1995	9/95
Write invention reports and patents	3rd Q, 1995	
Pursue additional industrial support and cost sharing	4th Q, 1995	
Evaluate field trials, begun in yr#2	1st Q, 1996	
Distribute progress reports	2nd Q, 1996	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	52	395,942
Hawaiian Commercial & Sugar	32	240,000
Donlar-Galbraith Intl.	8	94,174
Uniroyal Chemical	5	60,00
Cherry Marketing Institute	3	40,000
Total	**100**	**$830,116**

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* POC for project description updates.

NICE^3 PROJECT DATA

Paper Mill Optimization Through Closed-Loop Processing Technology

RECIPIENT: Simplex Products Div.

RECIPIENT PROJECT DIRECTOR: Charles Brinley (517) 263-8881

STATE: Michigan

DOE REGION: V

CONGRESSIONAL DISTRICT: MI-7

CONGRESSIONAL REPRESENTATIVE: Nick Smith (R)

SENATORS: Carl Levin (D) Spenser Abraham (D)

PROJECT NUMBER: 95-MI-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Michigan Public Service Commission
John Trieloff (517) 334-7233

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Simplex Products Division will install new technology and equipment as a prototype paper industry installation to remove dissolved solids in the internal process water at their Constantine, MI paper manufacturing facility. The goal of the project is to convert dissolved solids in process water to suspended solids using a new gas injection technology. The treated process waster can be reused internally in a closed-loop paper manufacturing process realizing energy, environmental, and production efficiencies.

PROCESS DATA: 150 TPD PAPER MILL

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	3.49×10^6 Btu/yr/unit	0.518 x 106 Btu/yr/unit	1.08×10^{12} Btu/yr
Environment (Waste Reduction)	29,108 tons/yr/unit	2,981 tons/yr/unit	9.56×10^6 tons/yr
Economics (Payback)	—	0.41 yr	—

TECHNICAL PERFORMANCE

Paper Mill Optimization Through Closed-Loop Processing Technology

Background

The Pulp and Paper Industry is nationally one of the largest users of water and energy for manufacturing. As the carrier and vehicle whereby papermaking cellulose fiber and papermaking fillers, additives and chemicals are mixed, blended and processed during the making of the sheet of paper, water is vital to the papermaking process. The Pulp and Paper Industry, particularly in the Great Lakes Region, has been under increased pressure to reuse process water more efficiently.

Paper manufacturing process water must be of good quality for the papermaking process to occur efficiently. Poor quality process water results in inefficient cellulose fiber bonding and is very detrimental to additive and chemical performance. Poor process water quality is caused by two main factors in the papermaking process: first, the presence of suspended solids in the form of cellulose fines and anionic trash, and second, the presence of dissolved solids. The paper industry has in recent years addressed suspended solids through new technology such as dissolved air flotation (DAF) clarifiers. But the dissolved solids issue, has not been adequately addressed and is the leading reason paper manufacturing systems need to replenish their process water with fresh water sources. This inability to reuse papermaking process water results in high waste and poor energy efficiency typically found in paper mills.

To address the dissolved solids problem, this proposal uses technology new to the paper mill in combination with existing paper manufacturing technologies. The paper mill site is Simplex Products Division's (SPD) Constantine, Michigan mill. This mill has proactively been addressing process water usage and has reduced the amount of process water discharged to only 500 gallons per finished ton. However, they have reached the threshold of dissolved solids buildup and cannot close the mill further without the application of new dissolved solids technology. The proposed technology uses a unique way to add and mix various gases into the process water that precipitates out the dissolved solids. The precipitated dissolved solids are then taken out of the process water using existing suspended solids process water filtration systems such as a DAF clarifier. The new dissolved solids remediation system can be applied internally to the papermaking process. This provides the unique opportunity to completely close the mills process water system, thereby eliminating effluent discharges and greatly increasing energy efficiency.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and appear to be progressing very slowly. This project may need some intervention to expedite negotiations.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

At this time there is no specific marketing or tech transfer plan in place. It is assumed that Aquatex, the major equipment supplier, will market the technology as a technology package throughout the pulp and paper and other applicable industries.

Milestones

Milestone	Planned	Actual / Revised
Western Michigan U. pilot plant testing	11/95	
Design system for Simplex	11/95	
Installation of system	12/95	
System Start-up	1/96	
Performance testing	1/96	
Data evaluation and compilation	2/96	
Commercialization begins - project complete	3/96	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	43	400,000
State	0	0
Industry	57	526,000
Total	**100**	**926,000**

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* POC for project description updates.

NICE^3 PROJECT DATA

Atmosphere Recovery and Regeneration in Heat Treating Operations

RECIPIENT: Dana Corp.

RECIPIENT PROJECT DIRECTOR: Paul Koehn (612) 559-6233

STATE: Minnesota

DOE REGION: V

CONGRESSIONAL DISTRICT: MN-6

CONGRESSIONAL REPRESENTATIVE: Bill Luther (D)

SENATORS: Paul David Wellstone (R) Rodd Grams (R)

PROJECT NUMBER: 95-MN-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Minnesota Dept. of Public Service
Michael Roelofs (612) 297-2545

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: High temperature furnace processes used in manufacturing (including heat treating, brazing, sintering and related operations) typically maintain reducing or inert gas "atmospheres" over parts being processed. In current industry practice, the waste RX and similar furnace atmosphere gases are discharged directly through natural gas-fired flares into ambient air. Dana proposes to install a full-scale operating prototype of a new technology to recover, clean and reuse over 90% the current RX furnace atmosphere gas.

PROCESS DATA: 10,000 FT^3 / HR RX GAS CAPACITY

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	35×10^9 Btu/yr/unit	4.1×10^9 Btu/yr/unit	170×10^{12} Btu/yr
Environment (Waste Reduction)	1,550 tons/yr/unit	155 tons/yr/unit	7.67×10^6 Tons/yr
Economics (Payback)	---	3.25 yr	—

TECHNICAL PERFORMANCE

Atmosphere Recovery and Regeneration in Heat Treating Operations

Background

High temperature furnace processes used in manufacturing (including heat treating, brazing, sintering and related operations) typically maintain reducing or inert gas "atmospheres" over parts being processed. A major heat treating operation of this type is "carburizing" primarily used to produce "case hardened" (hard and wear resistant) surfaces on steel parts. Parts to be carburized are typically placed in batch or continuous (conveyor driven) furnaces heated by natural gas or resistance electricity to temperatures of approximately 1750 degrees Fahrenheit (°F) in the presence of gaseous carbon monoxide (CO). The most common atmosphere used in carburizing is principally of a mixture of 20% CO, 40% hydrogen and 40% nitrogen (often called "RX" gas). As the RX gas contacts the hot part surfaces, some of the carbon in the CO portion dissolves into and combines with the surface steel. The released oxygen reacts with the hydrogen to form water vapor, and the nitrogen acts primarily as an inert gas.

The Dana Corporation (Dana) is a Fortune 100 corporation, the largest original equipment manufacturer (OEM) for the North American automotive industry, and the major producer of OEM automotive and heavy equipment axles, transmissions and brakes. Dana has 33 U.S. large manufacturing plants that carburize parts for its products.

In current industry practice, the waste RX and similar furnace atmosphere gases are discharged directly through one or more natural gas-fired flares into ambient air with no attempt at recycling, reuse or energy recovery. Prior to flaring, waste carburizing gas contains almost 200,000 parts-per-million (ppm) CO and elevated nitrogen and sulfur oxides. Following flaring, this waste carburizing gas contains from 40,000 ppm to 80,000 ppm CO, and the furnace discharge from a medium-sized facility averages 200 tons per year (TPY) of CO. An additional 100 TPY of CO is emitted from idling and spare RX generator capacity, since minimum flows must be maintained in the generators to produce an acceptable RX quality.

Dana proposes to install a full-scale operating prototype of a new technology to recover, clean and reuse over 90% the current RX furnace atmosphere gas at its Spicer Off-Highway Axle Division heavy axle facility in Minneapolis (Plymouth), Minnesota. This facility will have spare furnace capacity available to start, test, and prove the prototype technology on scrap and production parts over the project period. After their expansion, successful completion of the project will result in the 90% savings affecting one-half this plant's total carburizing capacity.

Technical Progress / Project Status

Contract: The grant and contracts have been signed by all parties and work has commenced.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

The proposing team has all the elements to commercialize the proposed technology once the full scale performance data is obtained and the economic assumptions validated. In conjunction with its industry vendor partners and initial customer, ARI intends to manufacture and market production atmosphere recovery and regeneration systems. Substantial financial support to construct and market the ARI process is anticipated from one or more of its partners and/or a major carburizing furnace vendor following this project.

Dana (world-wide) is anticipated to be a significant initial customer, and the implementation of the new Federal air emissions regulations a major incentive for additional system installations. Because of the manufacturing (and contractual) cost reductions the ARI process allows, Dana will conduct corporate-wide (and possibly vendor-wide) technology seminars to promote this technology (the first corporate-wide presentation is scheduled for May, 1995).

Project results will also be presented at this or next year's major heat treat industry trade show (sponsored by ASM International). As appropriate, the Dana, Plymouth facility will conduct plant tours for interested parties. The Minnesota Department of Public Service and the Minnesota Office of Environmental Assistance have offered to monitor the demonstration and publicize the results and findings. Once the technology is proven, the USEPA may adopt the ARI (or similar) process as its MACT emission control technology for heat treating operations because of its source reduction approach and favorable economics. The vendor partners in this project have extensive marketing and manufacturing capability in the heat treating industry and will be able to meet significant product demand, either through their manufacturing capabilities or through licensing agreements.

Milestones

Milestone	Planned	Actual / Revised
Final design and specifications of critical parts; prototype assembly begins	12/95	
Prototype connection to furnace and startup (with RX Atmosphere Backup)	2/96	
Atmosphere re-processing proved; full P2 operation starts	6/96	
Production parts processed; final quality and reliability testing starts	8/96	
Project completed; final report submitted	12/96	

Budget and Cost Sharing

Funding Source	% Cot Share	Amount, $
DOE	37	268,500
State	<1	5,000
Industry	63	450,000
Total	100	723,500

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* POC for project description updates.

NICE^3 PROJECT DATA

Brine Reuse in the Textile Industry

RECIPIENT: Sara Lee Knit Products

RECIPIENT PROJECT DIRECTOR: Donald Brown (910) 519-5610

STATE: North Carolina

DOE REGION: IV

CONGRESSIONAL DISTRICT: NC-12

CONGRESSIONAL REPRESENTATIVE: Melvin Watt (D)

SENATORS: Jesse Helms (R) Lauch Fircloth (D)

PROJECT NUMBER: 95-NC-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: NC Office of Waste Reduction
John Burke (919) 571-4100

DOE SUPPORT OFFICE: Tim Eastling (404) 347-7141

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Historically, salt and color have proven difficult and cost prohibitive to remove from discharged waters in the textile industry. A relatively new membrane technology, nanofiltration, combined with selected color removal technologies provides for the beneficial reuse and removal of these pollutants. Nanofiltration, utilized to filter selected "dumps" will reduce the volume of colored wastewater for treatment while providing for the beneficial reuse of brine solution in dyeing.

PROCESS DATA: ONE DYING UNIT (120,000 GALLONS OF RECOVERED BRINE WASTE /DAY)

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	28.4 x 10^9 Btu/yr	10.6 x 10^9 Btu/yr	800x 10^9 Btu/yr
Environment (Waste Reduction)	1.23 x 10^6 tons/yr	1.06 x 10^6 tons/yr	8.1x 10^6 tons/yr
Economics (Payback)	—	1.39 yr	—

TECHNICAL PERFORMANCE

Brine Reuse in the Textile Industry

Background

The United States Textile Industry is faced with a difficult problem with the wastewater generated in the dyeing processes. Of special concern are those wastes discharged from the production of cotton and cotton blend fabrics. These fabrics are for the most part dyed with a process in which there is a poor "yield" of the added dyestuffs and the required dyeing auxiliaries are characterized by high concentrations of non-biodegradable salts. The end result of the discharges are unacceptable color levels and toxicity in the receiving streams respectively. Color removal can be achieved but there are substantial capital and operational costs involved. Likewise technologies exist which can remove the salts from the waste stream but at prohibitively high costs. Whether removal is at the receiving POTW or on a private industrial site, the incurred treatment costs during these times of competitive World trade will put our textiles at a distinct disadvantage.

A current study presently being conducted by Sara Lee Knit Products proposes to treat only selected "drops" of the dye cycle resulting in a significant reduction in treatment volume as well as capturing the "drops" with the majority of the waste load. With this approach, less capital for equipment is required for the reduced volumes. Furthermore, the permeate from the filters will be suitable for reuse reducing the energy requirements to process and transport the recycled dyeing assistants present in the reuse stream. More specifically 96% of the sodium chloride in solution can be separated from the dyes, suspended solids, and other dyeing assistants. Instead of further costly refinements, previous trials have shown that this solution can be re-introduced to a dyecycle. This use would save the cost of the sodium chloride, the cost of that amount of process water, and the cost associated with the disposal of the wastewater. With the associated volume reduction of the colored bodies, suspended solids, and metals, dramatic downsizing of this treatment train can also be achieved.

Technical Progress / Project Status

Sara Lee knit products has received bids for the construction of the membrane filtration system that will be used to recycle brine. A contractor will be selected in January 1996, and the installation of the membrane system will begin February 1, 1996.

Contract: Contracts between the state and the industrial partners were signed November 11,1995.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

A commercialization plan has not been specified at this time.

Milestones

Milestone	Planned	Actual / Revised
Release of Filtration Unit PO	11/95	
Release of Phy/Chem equipment PO	11/95	
Installation Start	1/96	
System Start-up	2/96	
First operational report	5/96	
Second operational report	8/96	
Install in full size plant - Project Complete	10/96	

Budget and Cost Sharing

Funding Source	%	Amount, $
DOE	50	105,996
State	5	9,636
Industry	45	106,000
Total	**100**	**211,996**

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Industry:

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* POC for project description updates.

NICE³ PROJECT DATA

Ultraviolet Curing of Fiberglass Sleeving

RECIPIENT: NATVAR Co.

RECIPIENT PROJECT DIRECTOR: Vicky Bagley
(919) 553-4151

STATE: North Carolina

DOE REGION: IV

CONGRESSIONAL DISTRICT: NC-12

CONGRESSIONAL REPRESENTATIVE: Melvin L. Watt (D)

SENATORS: Jesse Helms (R) Lauch Faircloth (R)

PROJECT NUMBER: 95-NC-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: NC Energy Division
Curtis Phillips (919) 733-1895

DOE SUPPORT OFFICE: Tim Eastling (404) 347-7141

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: This project will assist in the implementation of a new process for ultraviolet curing of fiberglass sleeving manufactured for the electrical industry. The current process used to produce the electrical sleeving has not change since the 1920's. Fiberglass and acrylic plastic are the primary materials in the product. The acrylic plastic is now available in a form that can now be cured by UV instead of heat which will save energy, reduce pollution, and increase productivity.

PROCESS DATA: 1000 LINEAR FEET OF SLEEVING

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	10.8×10^6 Btu/yr/unit	$.40 \times 10^6$ Btu/yr/unit	2.2×10^{12} Btu/yr
Environment (Waste Reduction)	5.24×10^{-3} tons/yr/unit	1.69×10^{-4} tons/yr/unit	1895 tons/yr
Economics (Payback)	--	TBD	—

TECHNICAL PERFORMANCE

Ultraviolet Curing of Fiberglass Sleeving

Background

The NATVAR Company, located on Highway 70 East in Clayton, NC is a manufacturer of medical grade sleeving, electrical sleeving and medical subassemblies. The plant is divided along these product lines into the Medical Division and the Electrical Division. The principle product in the Electrical Division is coated fiberglass sleeving. The same insulation sleeving is sold to the electrical supply and distribution market for repair and maintenance of electrical appliances and machines.

The process used to produce the electrical sleeving was introduced during the 1920's and implemented at this plant about 20 years ago. The technology has not changed substantially since its introduction because the product remains a very low cost and reliable component to the OEM customers and there is no incentive to develop new products.

The best way to describe the process is to enumerate the different steps that the fiberglass braid goes through on its way to becoming a product. The first step is the loading of spools of the braid onto the de-reeler. A heavy steel ball is placed inside the sleeve to rotate as the sleeving is pulled through the station. The combination of heat and weight of the ball makes the fiberglass braid take on a cylindrical shape while the operation also cleans up the stray glass fibers on the braid and removes any impurities on the outside of the fiberglass. The sleeving next passes through a one gallon open dipping trough containing a pigmentation material. The sleeving then passes through a larger trough that is filled with acrylic plastic liquid mixed with water and a bonding agent. The trough holds approximately 20 gallons of clear acrylic liquid.

The next step is to thread the sleeve through the drying and bonding tower, located overhead of the plastic dip, to harden the plastic coating. The product is divided onto four different classes depending on the strength, heat resistance, and other parameters of quality. The goal of the project proposed herein is to prove the concept of ultraviolet light curing of the acrylic plastic used on the insulation sleeving and to put into operation the hardware necessary to run all of the acrylic production at the NATVAR plant.

The Fusion Systems Corp. has loaned UV curing equipment to NATVAR and to Actinic to further the experiments on the acrylic covered sleeving. In addition, they have specified the size and wattage of the required UV units to be used in the new production line along with the cost and frequency of lamp replacement.

Technical Progress / Project Status

Contract: Contract/grant negotiations are ongoing. This is a FY 1995 award.
Commercialization: None to date.
Benefits: None to date.

Technical Transfer

To assist in the dissemination of information on this technology to the target audience, the Energy Division of the North Carolina Department of Commerce will conduct a workshop on this technology at the end of the project. In addition, technical papers submitted to appropriate venues and magazine articles for trade publications will be written by the Energy Division Project Manager to assist in publicizing the technology.

The industry is much too sedate and settled to undertake the risk of this new product without this grant. The lines that run the product have been in place for years and everyone in the business is satisfied with their own share of the market. The product is a "commodity" type of low cost item that does not have a high profit return. Something needs to be done to "shake up" the entire industry to gain the savings in energy and pollution that the new UV cured product can bring.

Milestones

Milestone	Planned	Actual / Revised
Submit to U.L. for approval	11/95	
Begin preliminary product runs	3/96	
Optimize production line	9/96	
Begin production	11/96	
Follow-up assessment	7/97	
Conduct workshop	9/97	
Project complete	11/97	

Budget and Cost Sharing

Funding Source	%	Amount, $
DOE	49	62,500
State	2	2,500
Industry	49	61,600
Total	100	126,600

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* POC for project description updates.

NICE^3 PROJECT DATA

Onsite Aluminum Recycling: Automobile Wheels

RECIPIENT: AAP St. Marys

RECIPIENT PROJECT DIRECTOR: Daniel Hosek
(419) 394-7840

STATE: Ohio

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: OH-4

CONGRESSIONAL REPRESENTATIVE: Michael Oxley (R)

SENATORS: John Glenn (D) Howard Metzenbaum (D)

PROJECT NUMBER: 92-OH-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Ohio Department of Development
John Greenway (614) 466-7406

DOE SUPPORT OFFICE: Juli Politt (312) 886-8571

FISCAL YEAR AWARDED: 1992

PROJECT SCOPE: Introduce a new, more efficient technology for remelting the considerable volume of waste aluminum chips that are produced. Utilize automated conveyors to transport chips from the machining operation to the new remelting operation for recycling, incorporate a more efficient technology for remelting chips which will increase the yield of usable aluminum and employ a more efficient technology (a molten metal pump) for stirring the molten aluminum during the recycling process.

PROCESS DATA: 2.5 MILLION ALUMINUM WHEELS / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	25×10^9 Btu/yr	10×10^9 Btu/yr	0.4×10^{12} Btu/year
Environment (Waste Reduction)	1063.4 tons/yr	99.6 tons/yr	25,298 tons/year
Economics (Payback)	----	1.59 yr	—

TECHNICAL PERFORMANCE

On-site Aluminum Recycling: Automobile Wheels

Background

AAP St. Marys makes cast aluminum automobile wheels from ingots for domestic and foreign automobiles. Machining rough castings produces aluminum chips that are contaminated with cutting oils and coolant. The contaminated chips are trucked to an off-site recycler where the chips are cleaned and melted into ingots (as an intermediate step) for shipment back to AAP St. Marys where the ingot is again remelted into molten aluminum for casting wheels. This process creates a high amount of waste by-product and a new technology is needed for stirring the molten aluminum during the recycling process.

This project will introduce a new, more efficient technology for remelting the considerable volume of aluminum chips that are produced, thereby increasing the yield of usable aluminum by 6.5%. Automated conveyors will transport chips from the machining operation to the new remelting operation for recycling. A reduction in energy usage and costs associated with truck transportation of chips off-site will be realized as well as a 50% reduction in the number of times each batch of chips is remelted due to eliminating the need to recreate aluminum ingots as an intermediate step. Lastly, a new, more efficient technology for stirring the molten aluminum during the recycling process will be introduced. A molten metal pump will be employed to stir the molten aluminum more completely.

Technical Progress

During September, a total of 348 metric tons of chips were recycled. The most significant modification was the installation of a variable speed drive for the charging system. AAP recycled 378 tons of chips in October which is a new record. The monthly total of 359 tons of recycled chips in November exceeded the 300 tons/month target.

During the planned two week shutdown in December, AAP St. Marys installed new furnace refractory, changed the shape of the charge well for better circulation, lowered a new charger roof for a quicker melt, installed a larger metal pump to improve circulation, and installed six new burners to improve melting and improve fuel efficiency. 186 tons of chips were recycled during the two weeks of operation.

Milestones

Milestone	Planned	Actual/ Revised
Equipment Installation	2/93	3/93
System Debugging	3/93	4/93
Testing of Recycled Chip Products	3/93	ongoing
Full Utilization of Recycled Chips	10/93	10/93
Begin Evaluation of Project Results	1/94	1/94
Project/Grant Completion	5/31/94	7/95

Technology Transfer

AAP St. Mary's presented the evaluation of the new technology at the Industrial Energy Technology Conference in Houston, Tx, April 1994. They will respond to requests from othe industrial organizations via: 1) written abstract of the project; 2) videotape of the project; and/or 3) on-site demonstration of the project. Preliminary results were presented at the May 1993 Material Waste Reduction Review in Santa Fe, New Mexico as well as at the 1994 and 1995 OIT Annual Review Meetings. They have also given process tours to non-automotive related aluminum product manufacturers.

Commercialization: One unit in place at AAP St. Mary's plant operating efficiently and realizing benefits since June 1993.

Benefits: Aggregate energy savings: 38 billion Btu
Aggregate waste savings: 2410 tons of waste
Aggregate economic savings: $4,636,000

Budget & Cost Sharing

Funding Source	%	Amount $
DOE/EPA	16	200,000
State	3	30,000
Industry	81	1,037,000
Total	100	1,267,000

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* POC for project description updates.

NICE^3 PROJECT DATA

Real-Time Neural Networks for Combustion Optimization for Utility Boilers

RECIPIENT: Pegasus Tech.

RECIPIENT PROJECT DIRECTOR: Richard W. Vesel (216) 255-1808

STATE: Ohio

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: OH-19

CONGRESSIONAL REPRESENTATIVE: S. LeTourette (R)

SENATORS: John Glenn (D) Mike DeWine (R)

PROJECT NUMBER: 94-OH-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Ohio Dept. of Development
John Greenway (614) 466-7406

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8517

FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: This project proposes to modify existing off-line neural network-based advisory systems to optimize combustion settings for minimal NO_x and reduced SO_2 and CO_2 emissions while maintaining or improving plant thermal efficiency. The system will dynamically adapt and perform the specified functions during plant load and ambient condition changes. In many cases, this can eliminate the need for installation of low NO_x burners to meet regulatory requirements.

PROCESS DATA: 400 MEGAWATT PLANT

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	34.0 x 10^{12} BTU/yr/unit	33.7 x 10^{12} BTU/yr/unit	25 x 10^{12} BTUs/yr
Environment (Waste Reduction)	3.25 x 10^6 tons/yr/unit	3.21 x 10^6tons /yr/unit	1 x 10^6 tons/yr
Economics (payback)	—	2.5 yrs.	—

TECHNICAL PERFORMANCE

Real-Time Neural Networks for Combustion Optimization for Utility Boilers

Background

Nitrogen oxides resulting from the combustion of fossil fuels, especially NO and N02, have been recognized as significant hazards to the Earth's biosphere. These gaseous compounds are major precursors to ozone and photochemical smog formation, and represent minority constituents of acid rain. NOx has been associated with respiratory disorders, corrosion of materials, damage to vegetation, and visibility reduction due to light absorption in the visible portion of the spectrum.

NOx emissions from pulverized coal-fired boilers are sensitive to many factors, including temperature, stoichiometric conditions of the burner and furnace designs, fuel components, flame patterns, and secondary operating setpoints, such as draft level. NOx emissions result from elemental air combustion, flame front dynamics (so-called 'prompt NOx'), and fuel-bound nitrogen. ($S0_2$ emissions are a result of the burning of fuel-bound sulfur.) Combustion control techniques are able to address all three forms of NOx generation. Important contributions to combustion dynamics are made by the current plant maintenance conditions, which might indicate presence of varying degrees of inoperative equipment, corrosion, slagging, sooting, and boiler tube scaling.

The goal of this project is to modify an existing off-line neural-network-based advisory system to optimize combustion control settings for minimal NOx emissions, while maintaining or improving plant thermal efficiency, and reducing $S0_2$ and $C0_2$ emission levels. This neural net system was first implemented to monitor plant combustion processes and generate setpoint recommendations for heat-rate (thermal efficiency) optimization only.

Ultimately, the research will develop an on-line neural network NOx minimizer tied directly to the utility control system, such that dynamic targets minimize NOx production while maintaining the best possible heat rate (thermal efficiency). An added benefit of obtaining the best possible heat rate is that the raw production rate of carbon dioxide ($C0_2$) and sulfur dioxide ($S0_2$) are reduced before any post-combustion desulfurization treatments begin.

Technical Progress

Phase II testing of pulverizer outlet temperature and O_2 trim (5 different signals) in a 30 day closed loop control of these signals is complete and operated successfully. A significant reduction in NOx was observed along with improvement in heat rate and loss of ignition (LOI), unburned coal. NOx was reduced from 0.58 lb/MBtu to 0.48 lb/MBtu during the 30 day continuous testing period; a 17% decrease. Heat rate was improved by an average of 2%. A site visit was conducted in December by MACTEC, state, Pegasus, and Penn Power personnel. Ohio Edison / Penn Power have signed off on the last milestone for the project and the final report should be delivered in mid-January.

The technology will be transferred to another power plant in Ohio in the very near future and Pegasus has plans to expand the neural network to other setpoints within the power plant. This technology should disseminate rapidly throughout the utility industry once the results are marketed.

Technical Transfer

The Electric Power Research Institute (EPRI) is monitoring the progress of the beta testing of the recommendation systems. Once the actual feasibility of this modelling and control technique are demonstrated and proven in the field, a report will be generated and disseminated via EPRI to its members and the power utility community at large. Pegasus Technologies also intends to heavily promote and publicize the results of its program within industry publications, enabling customers and competitors alike to find out about the benefits of implementing such systems on a large scale.

Pegasus intends to reinvest a large portion of the net proceeds of the sales from the first ten systems into a well-executed marketing and sales campaign. In March of 1994, presentations were made to Westinghouse and the Utility Division of the Foxboro Company, and a progress paper was submitted to EPRI. Pegasus will be promoting this technology at the annual EPRI Heat Rate Conference, as well as through the American Power Conference. In addition to Pegasus' own efforts, AI WARE is using the NeuSIGHT program as a springboard for the publicizing of their unique technology and is scheduled to deliver the first of many planned papers in June, 1994.

Commercialization: one unit **Benefits:** Benefits are now being realized after the test period - 20% reduction in NOx emissions; 2% increase in thermal efficiency; payout in approximately 6 months due to reduced fuel costs (payout does not reflect cost savings from not having to purchase NOx reducing equipment or lost time from exceeding NOx limits).

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	42	100,000
State	15	35,000
Pegasus	43	104,600
Total	**100**	**239,660**

Milestones

Milestone	Planned	Actual
Control Parameter Database Developed & Installed	12/94	3/95
Verification of Effectiveness of Recommendation System	2/95	5/95
Control Parameter Communication	5/95	5/95
On-Line Control System Implemented w/Testing Initiated	8/95	8/95
Project Completed - Final Report Delivered	10/95	1/96

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* POC for project description update

Milestones

Milestone	Planned	Actual
Control Parameter Database Developed & Installed	12/94	3/95
Verification of Effectiveness of Recommendation System	2/95	5/95
Control Parameter Communication	5/95	5/95
On-Line Control System Implemented w/Testing Initiated	8/95	8/95
Project Completed - Final Report Delivered	10/95	1/96

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NICE^3 PROJECT DATA

Dense Fluid Extraction (DFE) Product Cleaning in an Industrial Application

RECIPIENT: Brush Wellman,Inc.

RECIPIENT PROJECT DIRECTOR: Andy Sandor (419) 862-4177

STATE: Ohio

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: OH- 9

CONGRESSIONAL REPRESENTATIVE: Marcy Kaptur (D)

SENATORS: John Glenn (D) Mike DeWine (R)

PROJECT NUMBER: 94-OH-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Ohio Dept. of Economic Development
John Greenway (614) 466-7406

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8517

FISCAL YEAR AWARDED: 1994

PROJECT SCOPE: The project will replace solvent vapor degreasing and a wash tank process to clean beryllium alloyed materials with dense fluid extraction cleaning. The new process will use CO_2 as the cleaning solvent with a CO_2 recovery system included to minimize CO_2 loss during the process. The proposed process will be environmentally safe, cost effective, and will minimize health and safety concerns for process operators while meeting or exceeding process capability/quality of the existing vapor degreasing system.

PROCESS DATA: 99,000 LBS Of PCE

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	3.68 X 10^{10} Btu/yr	2.0 X 10^{8} Btu/year	3.64 X 10^{10} Btu/yr
Environment (Waste Reduction)	3964.5 tons/yr	24.95 tons/year	15,075 tons/year
Economics (Payback)	—	3.6 yr	—

TECHNICAL PERFORMANCE

Dense Fluid Extraction (DFE) Product Cleaning in an Industrial Application

Background

Brush Wellman is a producer of beryllium and beryllium alloyed materials for domestic and foreign markets. Conventional technology uses Tetrachloroethylene (PCE) (Perchloroethylene) for the removal of oils and greases from rod, bar and tube products, and for cleaning beryllium machining chips prior to return as input to the raw product manufacturing process. Both of these processes create environmental and employee health concerns. The environmental concerns are air emissions, water contamination, soil contamination and wastewater treatment plant sludge contamination. Brush Wellman, Inc. has identified Dense Fluid Extraction (DFE) as having the greatest potential of successfully replacing PCE. General Technoscience, Inc., has developed this technology, under the name of DEFLEX (DEnse FLuid EXtraction). The problem is industry's reluctance to install the technology without full-scale testing results. This project focuses on overcoming the technical and economic barriers to implementation by testing on a full-scale and sharing results of energy savings and pollution prevention.

The goals of this project are: 1) to develop the DEFLEX process for the removal of oils and greases from rod, bar and tube products; 2) to demonstrate technical feasibility in this application; 3) to evaluate the cost-benefit impact of the technology on the industry; and 4) to share results to encourage widespread recognition and acceptance of the technology.

Technical Progress

The process design for the Rod, Bar and Tube process is basically complete. A CO_2 supplier has been selected and the storage pad is under construction. Team activities are progressing on schedule for developing project cost estimates for the Chip Cleaning Process. The fabrication and assembly commenced in December and be completed in April 1996 and the unit will be shipped and installed in May 1996. Deflex is currently developing a business strategy to improve cash flow which has been their primary problem in performing required work on the project.

Brush Wellman is currently installing new manufacturing equipment which may result in modifications to the CO_2 cleaning system to be delivered in May 1996. The May delivery may be afford BW time to consider design modifications. Brush Wellman continues to receive numerous calls requesting information on the CO_2 technology.

Technical Transfer

As an emerging technology, a major factor required to enhance commercialization is a demonstrated, successful industrial application of the process. The joint effort between Brush Wellman and Deflex will provide the first industrial application, with project completion scheduled in 1995. Brush Wellman performed an analysis of alternatives for replacement of PCE based cleaning systems and found the Deflex process to be the most energy efficient and most environmentally safe process with a reasonable return on investment.

The engineering associated with development of the process will be applicable to other industrial applications. Brush Wellman will provide potential customers with access to demonstrations of process capability and will share data and information to assist in the evaluation of applicability of the technology to specific process requirements.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual
Process Development/Conceptual Design	10/15/94	2/95
Subsystem Design/Development	12/15/94	5/95
Construction	1/15/95	10/95
System Integration/Test	3/15/95	11/95
Operation/Maintenance Manuals	4/15/95	
Site Preparation/Shipment	4/15/95	
Installation/Initial Test	6/15/95	
Start-up/Training	7/15/95	
Turn Over to Operations	8/15/95	
Optimize Operations	9/15/95	
Begin Demonstrations for Potential Users of Process Technology	10/15/93	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	33	400,000
Brush Wellman	67	805,000
Total	100	1,205,000

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NICE^3 PROJECT DATA

Fuel-Based Nitrogen Generator

RECIPIENT:	Ind. Gas Tech. Comm.	PROJECT NUMBER:	95-OH-2
RECIPIENT PROJECT DIRECTOR:	David Price (614) 873-8736	HQ PROGRAM MANAGER:	Alan Schroeder (202) 586-1641
		GO PROJECT MANAGER:	Doug Hooker (303) 275-4780
STATE:	Ohio	LEAD STATE AGENCY:	Ohio Dept. of Development John Greenway (614) 466-7406
DOE REGION:	V		
CONGRESSIONAL DISTRICT:	OH-7	DOE SUPPORT OFFICE:	Juli Pollitt (312) 886-8571
CONGRESSIONAL REPRESENTATIVE:	David L Hobson (R)	FISCAL YEAR AWARDED:	1995
SENATORS:	Mike DeWine (D) John Glen (D)		

Project Scope: This project will show the energy savings and environmental benefits of the Fuel-Based Nitrogen Generator (FBNG). The program's goal is to install and operate FBNG units at two industrial sites in Ohio; a chemical plant and a food processing plant. Each installation will produce a nitrogen (N_2) atmosphere with a composition tailored to the user's needs. Operational data will be collected to verify energy efficiency, emissions, and consistency of atmosphere chemistry.

PROCESS DATA: ONE FUEL BASE GENERATOR PRODUCING TEN BILLION FT^3 OF N_2 /YR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	11.7 x 10^9 Btu/yr/unit	57.8 x 10^9 Btu/yr/unit	10.5 x 10^{12} Btu/yr
Environment (Waste Reduction)	828 tons/yr/unit	410 tons/yr/unit	759500 tons/yr
Economics (Payback)	—	1.1 yr	—

TECHNICAL PERFORMANCE

Fuel-Based Nitrogen Generator

Background

The U.S. consumes approximately 835 billion cubic feet (Bcf) of N_2 annually. The primary energy source used to manufacture N_2 is electricity to drive compressors. The FBNG uses about half the electrical energy of existing technologies. This creates the opportunity to substantially reduce electrical power consumption and associated emissions from both industrial facilities and power generation plants. Lower electrical energy requirements to produce high-purity N_2 is the foundation of this proposal.

Most N_2 is produced by a cryogenic process of air liquefaction and fractional distillation. About 20 kWh per 1,000 cubic feet (Mcf) is used to produce and store liquid N_2. Additional energy is used to distribute N_2 by truck or pipeline. By 2010, the total amount of N_2 consumed is projected to be 2010 Bcf. This is based on a projected annual growth of 5%. Most of this growth will come from non-cryogenic processes, which currently produce 6% of the N_2. A growth rate of 1000% for non-cryogenic N_2 is projected, growing from 50 Bcf per year (BcfY) to more than 600 BcfY.

The feedstock for current N_2 production technologies is air. As a result, if a N_2 based atmosphere containing another gas, such as hydrogen, is needed, this gas must be obtained separately and blended with the N_2. This has a significant economic impact. The feedstock for the FBNG is combustion products. Stoichiometric combustion of natural gas and air produces combustion products of CO_2, H_20, and N_2. Removal of the CO_2 and H_20 leaves a stream of N_2. Since most industrial plants have boilers, the preferred feedstock for the FBNG is the flue gas from a boiler.

The FBNG was developed to satisfy high purity requirements of customers. Much of this was achieved by design changes to the exothermic generator using technology developed within other industrial segments. The end product is a new process utilizing appropriate components and controls to produce high-purity N_2. The O_2 removal catalytic reactor in the FBNG also eliminates NOx from the boiler flue gas. H_2 is used as a reducing gas over a noble metal catalyst to remove trace amounts of O_2 and NOx.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be complete by February 1, 1996.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

Large industrial gas companies have traditionally sold cryogenic N_2 to both large and small users. It is expected that many industrial gas suppliers will include the FBNG in their array of N_2 processes. There are no legal or technical barriers to prevent this. In addition, ERCC is now negotiating with three different manufacturers that have expressed interest in manufacturing FBNG units. ERCC is a small corporation with the capability to provide 10 to 20 units per year. It appears that two FBNG units will be sold to metal heat treaters as a result of the upcoming successful demonstrations.

Manufacturers are reluctant to move away from a standard technology to a new one until a number of successful installations are in operation. Inertia prevents change even if economic and environmental advantages exist. The goal in this program is to overcome this inertia barrier with two successful field demonstrations.

Milestones

Milestone	Planned	Actual / Revised
Confirm Demonstration Sites 1 & 2	11/95	
Design and engineer site 1	10/95	
Build and install site 1	4/96	
Complete data acquisition for site 1	7/96	
Build and install site 2	8/96	
Complete data acquisition for site 2	11/96	
Submit final report - Project complete	12/96	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	45	283,500
State	0	0
Industry	55	350,500
Total	**100**	**633,500**

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* POC for project description updates.

NICE^3 PROJECT DATA

Innovative Technology for Reprocessing Uncured Rubber

RECIPIENT: Air Products & Chemicals

RECIPIENT PROJECT DIRECTOR: Robert Miller (610) 481-44780

STATE: Ohio

DOE REGION: V

CONGRESSIONAL DISTRICT: OH-4

CONGRESSIONAL REPRESENTATIVE: Michael G. Oxely (R)

SENATORS: John Glen (D) Mike DeWine (D)

PROJECT NUMBER: 95-OH-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Ohio Department of Development
John Greenway (614) 466-7406

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Air Products and their partners Midwest Elastomers and Nelmore Corp. will develop a new and economically viable process that will non-destructively convert the uncured rubber scrap generated during rubber manufacturing processes into a physical form that can be effectively used, thereby minimizing the waste stream from the process. The partners propose to design, construct, and operate a commercial scale (1000 lbs/hr) demonstration plant.

PROCESS DATA: RECYCLING TWO MILLION POUNDS OF RUBBER/YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	133×10^9	18×10^9	6.04×10^{12}
Environment (Waste Reduction)	10023 tons/yr/unit	1161 tons/yr/unit	469,633 tons/yr
Economics (Payback)	—	TBD	—

TECHNICAL PERFORMANCE

Innovative Technology for Reprocessing Uncured Rubber

Background

In the current manufacture of most all rubber goods, large amounts of uncured rubber are generated and processed in an intermediate step. Due to manufacturing defects, mistakes in manual handling and in construction, a small percentage of the uncured rubber processed is scrapped. Of particular concern is in the manufacturing of fines which represents the largest single use of rubber. The uncured scrap, because of its softness, tackiness, and high toughness, cannot be easily processed and reused. Therefore, more than 50 tire plants across the United States generate 50,000 to 200,000 lbs/month each of uncured rubber scrap (about 100 million lbs/year total) that is permanently landfilled or incinerated. In addition, hundreds of rubber molding plants across the nation also send uncured scrap rubber to landfills. These producers are faced with high continually rising disposal expenses and are creating an environmental hazard.

The objective of this proposed project is to demonstrate a new commercially viable cryogenic process jointly developed by Air Products, Midwest Elastomers, and Nelmor that converts uncured rubber scrap into a reusable form of powder that can be effectively used in tire and rubber molding plants. There is no commercially viable technology available today to non-destructively process and convert waste uncured rubber into a form whereby it can be effectively used as a feedstock supplement in a rubber plant.

The proposed concept is based upon the following sequence: product feeding, guillotining, subambient granulation, cryogenic milling, screening, and bulk storage. Proprietary partitioning agents of varied amounts are added at critical locations within the sequence. These agents are the keys to facilitating the production of fine particles during the uncured rubber processing. The generation of a fine, homogeneous powder is essential if it is to be reused in the rubber and tire manufacturing process and/or to be used as a supplementary feedstock for new/other rubber products.

Technical Progress / Project Status

Contract: This is a FY 1995 award. Contract/grant negotiations are ongoing and should be complete by February 1, 1996.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

A key aspect of the commercialization strategy is to invoke participation of various tire and rubber goods manufacturers. This will be accomplished from the very early stage of the project and throughout the demonstration operating period in order to satisfactorily evaluate the technical and economic feasibility of the technology with respect to each type of uncured rubber produced by different manufacturers. Both Goodyear and Michelin have expressed extreme interest in participating in the technology development, so much so that each has insisted upon exclusive rights to the technology. Once the use of uncured product is qualified by a given producer, it is the intention of the industrial partners to negotiate agreements whereby the uncured scrap rubber will be purchased from the rubber producer, processed on a fee basis, and returned to the process.

Our plan is to market the process initially to the 50+ tire plants in the U.S., and only move to international applications after a significant number of U.S. plants are operating successfully. It is envisioned that 5 - 20 tire plants/year could easily be accommodated after the initial commercial demonstration.

Milestones

Milestone	Planned	Actual / Revised
Lab processing to optimize process	12/95	
Design and procurement of system	2/96	
Installation / start-up at Midwest Elastomers	7/96	
Operation, evaluation, and optimization of system and rubber reuse	9/96	
Commercial operation ongoing - submission of final report - Project complete	12/96	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	47	400,000
State	0	0
Industry	53	448,076
Total	**100**	**848,076**

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* POC for project description updates.

NICE^3 PROJECT DATA

Hydrochloric Acid Recovery System

RECIPIENT: Beta Control Systems, Inc.

RECIPIENT PROJECT DIRECTOR: Bryan Cullivan (503)646-3399

STATE: Oregon

EPA / DOE REGION: X

CONGRESSIONAL DISTRICT: OR-1

CONGRESSIONAL REPRESENTATIVE: Elizabeth Furse (D)

SENATORS: Mark Hatfield (R) Bob Packwood (R)

PROJECT NUMBER: 93-OR-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Oregon Dept. of Energy
Mark Kendall (503) 378-8444

DOE SUPPORT OFFICE: Roxanne Dempsey (206) 553-2155

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: Develop a small-scale successful HCl recovery system ($200,000 range for the smallest unit). This system will be a closed-loop, cost-effective method available for on-site recovery needs of galvanizers and small- to medium-sized steel manufacturers. This system is based on Beta's proprietary design and engineering techniques, incorporating recent advancements in materials technology and automated controls. System introduction into the marketplace will follow.

PROCESS DATA: 125 TONS OF RECYCLED HCl / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	8,288 x 10^6 Btu/yr/unit	3,000 Btu/yr/unit	522 x 10^9 Bru/yr
Environment (Waste Reduction)	200.5 tons/yr/unit	0.5 tons/yr/unit	42,000 tons/yr
Economics (Payback)	—	1.4 yr	—

TECHNICAL PERFORMANCE

Hydrochloric Acid Recovery System

Background

Historically, hydrochloric acid (HCl) recovery technology has only been applied to large scale installations costing more than $2 million or more. There is currently no cost-effective method available for the closed loop, on-site recovery needs of smaller plants in the industry. Beta, over the past five years, has been developing a HCl Recovery System and is seeking funds to advance this new system through the pilot testing phase and introduce it into the marketplace. To date, Beta's Sulfuric Acid Recovery System services 85% of the U.S. galvanizing plants utilizing sulfuric acid to pickle steel.

Installation of an HCL recovery system would mean waste recovery at the source, improved final product quality, elimination of process tank downtime, saved disposal costs and the associated cradle-to-grave liability. Further, a non-hazardous saleable by-product, ferrous chloride, is generated through the recycling process. This by-product has applications in fertilizer, animal feed, waste treatment and as an etchment.

Beta is dedicated to developing a small-scale successful HCl recovery system ($200,000 range for the smallest unit). This system will be a closed-loop, cost-effective method available for on-site recovery needs of galvanizers and small- to medium-sized steel manufacturers. Beta will complete the development and testing phases of this new, pilot HCl recovery system and introduce it into the marketplace. This system is based on Beta's proprietary design and engineering techniques, incorporating recent advancements in materials technology and automated controls. Beta has created an elegantly simple process designed to last and be cost-effective.

Technical Progress

The first commercialized system is up and operating successfully at the Cal West galvanizing plant in Carson, CA. Judging from the interest and attention to the first commercial unit, commercialization could be very rapid. There are no technological barriers to this project's success. A 4-color brochure has been completed and will be sent out to 150 galvanizers in the Midwest. Beta made a presentation at the Northwest Industrial Forum on the NICE^3 process and how they benefited from the grant award. The project is essentially complete. A final report has been submitted to the state and DOE for comment. Several potential sales are pending based on the success of the CalWest unit. This will be the last active project report.

Milestones

Milestone	Planned	Actual/ Revised
Graph optimal final concentrations of acid for return to the process	Sep-Nov 1993	Oct 1993
Determine correct operating temp. for fluid at various process stages	Sep-Nov 1993	Oct 1993
Establish correct process flow rates	Sep-Nov 1993	ongoing
Determine byproduct material volumes	Sep-Nov 1993	Nov 1993
Preliminary Evaluation of test results	Dec-Feb 93/94	Jan 1993
Install Prototype at Carson, CA Plant and Evaluate System	Mar-May 1994	Jun 1995
Introduce to marketplace/environmental community	Sep 1994	Jan 1996

Technical Transfer

80% of Beta's current sales are to the galvanizing industry in the form of sulfuric acid recovery and rinse water recovery systems. Beta will introduce HCl recovery systems to existing markets. When the HCl acid recovery system is ready for introduction to the marketplace, the untapped 60% of galvanizers using HCl acid to pickle will have a solution for their waste. This recovery system will aid Beta in penetrating the steel manufacturing market which is dominated by HCl acid-based pickling. Specialty metals and electronics markets are potential future markets for this system. The system will be marketed domestically and abroad.

Commercialization: One unit in place since October 1995.

Benefits: Aggregate energy savings: .6 billion Btu
Aggregate waste savings: 70 tons of HCl
Aggregate economic savings: $ 40,000

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	43	105,304
State	17	40,304
Industry	40	100,000
Total	100	245,608

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*** POC for project description updates.**

NICE^3 PROJECT DATA

Cullet (Glass) Feedstock Purification Using Advanced Optical Sortation

RECIPIENT: Alpine Technology

RECIPIENT PROJECT DIRECTOR: Jim Mitchell (503) 484-5312

STATE: Oregon

EPA / DOE REGION: X

CONGRESSIONAL DISTRICT: OR-4

CONGRESSIONAL REPRESENTATIVE: Peter DeFazio (D)

SENATORS: Mark Hatfield (R) Bob Packwood (R)

PROJECT NUMBER: 93-OR-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Oregon Dept. of Energy
Mark Kendall (503) 378-8444

DOE SUPPORT OFFICE: Roxanne Dempsey (206) 553-2155

FISCAL YEAR AWARDED: 1993

PROJECT SCOPE: Alpine Technology proposes to build and demonstrate new process technology to purify feedstock (cullet) used by the glass container manufacturing industry and recycled material recovery facilities. Alpine's technology removes ceramic and other contaminants from cullet feedstock utilizing optical sensors and computer controlled jets of compressed air. Alpine will conduct capability studies, optimize optical sensing devices and calibration procedures and develop performance specs.

PROCESS DATA: 50,000 TONS OF WASTE MATERIAL / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	312×10^9 Btu/yr/unit	262×10^9 Btu/yr/unit	4.9×10^{12} Btu/year
Environment (Waste Reduction)	40,000 tons/yr/unit	10,000 tons/year/unit	3.4×10^6 tons/yr
Economics (payback)	—	2.8 yr	—

TECHNICAL PERFORMANCE

Cullet (Glass) Feedstock Purification Using Advanced Optical Sortation

Background

Alpine Technology proposes to build and demonstrate new process technology to purify feedstock (cullet) used by the glass container manufacturing industry and recycled material recovery facilities. Alpine's technology removes ceramic and other contaminants from cullet feedstock utilizing optical sensors and computer controlled jets of compressed air. The Glass Division report of the Oregon Recycling Markets Development Council has found that the major barrier of "cullet contamination" must be overcome for increased amounts of the feedstock to be utilized.

Alpine seeks to demonstrate ceramic sortation technology it has developed. In conjunction with the Oregon Dept. of Energy and Oregon State University, Alpine will conduct capability studies, optimize optical sensing devices and calibration procedures and develop performance specifications. The equipment will be built and installed at the regional materials recovery facility (MRF) being developed at Phoenix Industrial Park in Eugene, Oregon.

Alpine Technology and associated partners propose to:

- Develop performance criteria and specifications with regard to ceramic rejection technology for use by glass manufacturers and recycled material recovery facilities, the primary suppliers of cullet feedstock.
- Demonstrate the effectiveness of Alpine's sortation technology with regard to contaminant rejection efficiency, glass loss and throughput in an industrial setting and to verify and document waste reduction and energy savings.
- Research and identify optimal sensor sensitivity settings, conveyor size, conveyor speed and calibration technologies and to determine the need for other cullet conditioning equipment (i.e., dryer, paper classification, metal removal, etc.).

Technical Progress

The demonstration has bee delayed until the new light source and control unit is assembled for industrial application. Investors have expressed interest in acquiring the glass sortation system once the light source is resolved. OSU is confident that the three phase, one medium pressure mercury lamp per phase, system will overcome lamp life dilemmas. It has all of the potential for technical feasibility. Alpine has asked for a grant extension through June 1996 to accommodate modifications to the light system. OSU has been testing the modified board and line scan camera with positive results. The grant extension will allow Alpine to install the new system in a commercial setting and conduct tests to verify the commercial potential of the unit.

Technical Transfer

Concurrent with the demonstration project, Alpine will update its current list of glass container plants, MRFs, and related engineering and industry contacts (domestic and internationally). Information will be provided to prospective customers and interested parties. Sales materials will be developed along with a distribution and service organization. Alpine has several interested customers awaiting the outcome of the study such as Coors, Anhauser Busch, Owens-Brockway, Gallo and Fivbers International.

Commercialization: None to date.
Benefits: None to date.

Milestones

Milestone	Planned	Actual/ Revised
Grant Award/Contracting	4th Q/ 1993	1st Q/ 94
Preliminary Design Complete	1st Q/ 1994	1st Q/ 94
Research Optics/Mechanical Initiated	2nd Q/ 1994	2nd Q/94
Structural Systems Assembled	3rd Q/ 1994	3rd Q/94
Electrical Systems Assembly	4th Q/ 1994	4th Q/94
Initial Testing and Operation	1st Q/ 1995	4th Q/94
Evaluation Initiated	2nd Q/ 1995	4th Q/94
Evaluation Complete	3rd Q/ 1995	4th Q/94
Modifications and Final System Commissioning	4th Q/ 1995	1st Q/96
Marketing Plan Implemented	1st Q/ 1996	ongoing
Final Report	1st Q/ 1996	2nd Q/96

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	40	400,000
Oregon	17	175,000
Industry	38	386,730
Oregon State University	5	47,450
Total	100	1,009,180

Points of Contact:

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*** POC for project description updates.**

NICE^3 PROJECT DATA

Direct Osmosis / Solar Evaporation: Food Processing

RECIPIENT:	Osmotek, Inc.	**PROJECT NUMBER:**	94-OR-1
RECIPIENT PROJECT DIRECTOR:	Keith Lampi (503) 753-1297	**HQ PROGRAM MANAGER:**	Alan Schroeder (202) 586-1641
STATE:	Oregon	**GO PROJECT MANAGER:**	Doug Hooker (303) 275-4780
EPA / DOE REGION:	X	**LEAD STATE AGENCY:**	Oregon Dept. of Energy Mark Kendall (503) 378-8444
CONGRESSIONAL DISTRICT:	OR-04	**DOE SUPPORT OFFICE:**	Roxanne Dempsey (206) 553-2155
CONGRESSIONAL REPRESENTATIVE:	Peter DeFazio (D)	**FISCAL YEAR AWARDED:**	1994
SENATORS:	Mark Hatfield (R) Bob Packwood (R)		

PROJECT SCOPE: Production of tomato sauce, tomato paste, and catsup is very energy intensive because 75% to 90% of the (tomato) water must be removed depending on product consistency. Common industry practice is to remove water by using double effect evaporators powered by natural gas or diesel fuel. In this project, the water removal from puree will be accompanied by direct osmosis concentration. Water absorbed by the salt brine from osmosis will be removed by solar evaporation with no consumption of fossil fuels.

PROCESS DATA: 65,000 LBS OF EVAPORATED WATER

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	97.5 x 109 Btu/yr/unit	2.6 x 10^9 Btu/yr/unit	4.8 x 10^{12} Btu/yr
Environment (Waste Reduction)	7.9 x 10^9 tons/yr/unit	0.19 x 10^9 tons/yr/unit	386,000 tons/yr
Economics (Payback)	—	6.3 yr	—

TECHNICAL PERFORMANCE

Direct Osmosis / Solar Evaporation: Food Processing

Background

Production of food products such as tomato sauce, tomato paste, catsup, and pizza sauce is very energy intensive because fresh tomatoes are 95% water. In all of these products, between 75% and 90% of the water must be removed from the single-strength puree to provide the desired product consistency. Common industry practice is to accomplish this removal by use of double effect evaporators powered by natural gas or diesel fuel.

In this project, the water removal from the puree will be accomplished by direct osmosis concentration. Water absorbed by the salt brine will be removed by solar evaporation with no consumption of fossil fuels. The process will be competitive in the marketplace because it compares favorably to double-effect evaporators in capital and operating costs, energy costs, and product quality. Two commercially viable processes are combined in a unique way. Direct osmosis concentration (DOC) has been pioneered by Osmotek and is in the first phases of commercialization. Solar evaporation is a proven technology, with many current commercial applications. The combination of DOC and solar evaporation has never been commercialized. Specifically, what is being proposed is a three phase project: 1) The system will be installed at Stahlbush Island Farms (a local puree producer) and will process 2,500 lbs/day of tomatoes in a single eight hour shift for 20 days; 2) expand and relocate the plant to central California to a 50,000 lbs-tomato/day system to focus on demonstrating the reliability of the equipment; and 3) develop new markets for the cold concentrate.

Technical Progress

The tomato dewatering demonstration at UC Davis, which involved several major tomato processors, proved to be very successful and all parties were pleased with the test results. There does not appear to be any technological barriers to commercializing this technology. Osmotek is currently negotiating to scale up commercial systems with several interested parties that participated in the UC Davis tests.

Sabrosso of Medford, OR began installing a DOC unit to process speciality products during the fall of 1995. They also made a presentation at the NW Industrial Forum on the DOC/Osmotek process. Presentations were made by Osmotek to the Professional Energy Managers and to a citrus growers group. The presentations were met with positive responses.

Technical Transfer

Osmotek is already commercializing the DOC/conventional-evaporation technology. For the past two years, Osmotek has produced wine-grape concentrate commercially, and expects equipment sales in other areas this year for the DOC process. Several producers of specialty fruits and vegetables are waiting to buy systems when the mass-produced DOC modules are released by Osmotek. These producers all intend to use corn syrup as the OA and reconcentrate with an evaporator. It should be emphasized that the costs of DOC for these producers will be much higher than if they evaporate the product directly. The producers are willing to pay the incremental expense of DOC because the improvement in product quality more than compensates for the added cost.

After testing at Sabrosso and UC Davis, it is planned for the first customers to be small-scale producers of premium products. The first sales should come in 1996 and be 10,000 lbs-water/hour systems. Sales should ramp up until by the year 2010, 25% of U.S. tomato puree production is processed by DOC using solar ponds or R/O systems.

Osmotek has already made numerous contacts in Latin America, and is currently negotiating sales of DOC systems in the Caribbean for specialty fruits. A major export market will be created by American and international companies installing DOC equipment in tropical regions.

Commercialization: None to date.

Benefits: None to date.

Milestones

Milestone	Planned	Actual / Revised
Begin 2,500 lb-tomatoes/day demonstration at Stahlbush Island Farms, Corvallis, OR	9/94	12/94
Begin 50,000 lb-tomatoes/day trials at UC Davis with up to 5 companies	3/95	8/95
Develop new markets for cold concentrate	10/95	ongoing
Project completed	10/96	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	36	395,194
State	2	19,000
Osmotek, et al.	23	245,545
Stahlbush Island Farms	12	125,000
Tri-Valley Growers	27	300,000
Total	100	$1,084,739

Points of Contact:

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* POC for project description updates.

NICE^3 PROJECT DATA

Manufacturing Pallets with Recycled Thermoplastic/Cellulose Composites

RECIPIENT: Environmental Solutions, Inc.

RECIPIENT PROJECT DIRECTOR: Paul Blake (703) 264-7445

STATE: Virginia

DOE REGION: III

CONGRESSIONAL DISTRICT: VA-3

CONGRESSIONAL REPRESENTATIVE: Thomas J Biley

SENATORS: John Warner (D) Charles Robb (D)

PROJECT NUMBER: 95-VA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Innovative Technology Authority
Jack Heinmann (703) 689-3006

DOE SUPPORT OFFICE: Maryanne Daniel (215) 656-6964

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: The focus of this project is to commercialize a pallet product made of a thermoplastic peanut hull composite using a proprietary patented process that is under license to Birdsong Peanut Co. and Environmental Solutions Inc. Thermoplastic peanut hull composites are materials made from industrial waste peanut hulls and waste thermoplastic which acts as a glue that binds the waste peanut hulls together. Thermoplastic pallets require 91% less energy than polyethylene pallets and 58% less than lumber pallets.

PROCESS DATA: 250,000 PALLETS/YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	96×10^9 Btu/yr/unit	40×10^9 Btu/yr/unit	33.2×10^{12} Btu/yr
Environment (Waste Reduction)	6,562 tons/yr/unit	0	3.89×10^6 tons/yr
Economics (Payback)	---	1.93 yr	—

TECHNICAL PERFORMANCE

Manufacturing Pallets with Recycled Thermoplastic/Cellulose Composites

Background

The focus of this project is to commercialize a pallet product made of a thermoplastic peanut hull composite using a proprietary patented process that is under license to Birdsong Peanut Co. and Environmental Solutions Inc. Thermoplastic peanut hull composites are materials made from industrial waste peanut hulls and waste thermoplastic which acts as a glue that binds the waste peanut hulls together.

The *Pressaire*™ process being utilized takes waste thermoplastic fluff material and mixes it with peanut hull waste in an ambient temperature mixing process. A key factor of this process is that the thermoplastic fluff suspends the peanut hulls in the mixture and thereby allows even distribution of the thermoplastic glue throughout the mix. By evenly distributing the plastic in the mixture before it is heated avoids the problems found with high viscosity glues. The fluff mixture is then heat compressed to form a hot, loosely bonded wood/plastic mat that is transferred to a high pressure mulit-opening consolidation press where the material is densified, cooled, and formed into the final product.

The *Pressaire*™ process is perhaps the most energy efficient process available to make thermoplastic/cellulose composites since almost all of the energy is used to melt the plastic. In terms of pounds of material produced, it takes 91% less energy to produce than polyethylene, and 58% less than lumber. One major advantage of the thermoplastic/cellulose composites are that they are completely closed-loop recyclable material; any waste material resulting from fall down or mishandling can simply be ground up and made into a new pallet.

Technical Progress / Project Status

Contract: Contract/grant negotiations are ongoing. This is a FY 1995 award.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

The *Pressaire*™ material will be marketed under the name Nuevowood by Environmental Solutions and commercialization will begin at Birdsong peanuts where they will manufacture the pallets and are expected to buy back up to 20% of the product. The remaining inventory will be marketed to Birdsong's customers and then to the peanut industry as a whole.

Upon reaching full-scale production, the technology will be transferred to seven other Birdsong plants in the U.S. At this point the marketing will be regional in the South and will begin to expand beyond the peanut industry. Since the peanut industry is seasonal and there will not be enough peanut hulls to satisfy a large pallet market, other sources of cellulose such as straw, rice, and wood chips will be explored. In addition, this process may expand to other wood-like products such as doors, siding, and moldings.

Milestones

Milestone	Planned	Actual / Revised
Complete design and testing	12/95	
Complete Equipment design modifications	12/95	
Plant design complete	1/96	
Begin installation	3/96	
Complete trial runs	6/96	
Marketing plan implemented	9/96	
Full production - final report submitted- Project Complete	12/96	

udget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	24	425,000
State	1	24,000
Industry	75	1,339,400
Total	**100**	**1,764,400**

Points of Contact

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* POC for project description updates.

NICE^3 PROJECT DATA

Innovative Blanching Technology for Food Processing

RECIPIENT: Key Technology, Inc.

RECIPIENT PROJECT DIRECTOR: Randy Unterseher (509) 522-3371

STATE: Washington

EPA / DOE REGION: X

CONGRESSIONAL DISTRICT: WA-5

CONGRESSIONAL REPRESENTATIVE: George Nethercutt (D)

SENATORS: Slade Groton (D) Patty Murray (R)

PROJECT NUMBER: 95-WA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: WA Energy Office
Virginia Haas (360) 956-2171

DOE SUPPORT OFFICE: Roxanne Dempsey (206) 553-2155

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Key Technology of WA has developed and tested an innovative blanching technology that recirculates and re-uses the steam, dramatically reducing water and energy as well as reducing the generation of wastewater. Key will also demonstrate a new process control system that during blanching will test products for a key enzyme indicator which will reduce blanch times while providing higher quality food products.

PROCESS DATA: 23,400 TONS OF PRODUCT/YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	33.9×10^9 Btu/yr	9.97×10^9 Btu/yr	1.93×10^{12} Btu/yr
Environment (Waste Reduction)	22,372 tons/year	4,560 tons/year	9.4×10^6 tons/yr
Economics (Payback)	---	1.65 yr	—

TECHNICAL PERFORMANCE

Innovative Blanching Technology for Food Processing

Background

The processed food industry is the nation's largest manufacturing sector with approximately $404 billion in shipments. The U.S. food industry leads the world in its ability to convert raw commodities to finished products with the highest value added. Exports of value added processed foods rose 12% between 1991 and 1992.

Many food products within the food sectors are frozen or canned for final distribution and sale. In preparation for freezing and or canning, a blanching process is used to inactivate the enzymes and bacteria that would cause the foods to otherwise deteriorate and have shortened shelf life. The blanching process involves high temperature heating of raw product to 200-212^0 F by water or steam. Current blanching practices produce large quantities of wastewater effluent and use energy inefficiently. One study indicates the blanching process used 41% of all energy with pea processing.

The proposed project will demonstrate several changes to existing blanching techniques including a fully insulated steam cabinet, hydrostatic seals to reduce evaporation, circulation and re-use of energy medium on an as-needed basis, and sensory process technology that will further shorten blanch process times. These innovations will directly reduce energy use in blanching.

Technical Progress

Contract: Contract negotiations continue between Key Technology, Inc. and the state and should be finalized by February 1, 1996. Key is negotiating with Dean Foods in WI to test their process on a variety of Dean food products.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

On completion of the scale-size blancher, a group of targeted customers with various products will be asked to participate in testing of the technology. Special incentives from Key Technology will be offered to adopt first unit use in their commodity. These incentives may included discounted pricing, special terms, on-going monitoring and support of data collection

Through the ongoing customer feedback, additional market acceptance can be generated. The in-house marketing staff and sales force can utilize their resources to take this product to full commercialized status. Key Technology, in business since 1948, has a proven track record in the food processing industry.

Milestones

Milestone	Planned	Actual / Revised
Complete design of scale size blancher & lipoxygenase sensor	3/96	
Build scale size blancher with lipoxygenase sensor	6/96	
Test technology in pilot plant	9/96	
Phase 1 product testing - lab	11/96	
Phase 2 product testing - In-plant	3/97	
Demo technology relating to french fry production	6/97	
Apply for patent - Project complete	9/97	

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	48	155,411
State	5	15,000
Industry	47	152,759
Total	100	323,170

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NICE^3 PROJECT DATA

Ink Jet Supply and Printer and Solvent Recovery System

RECIPIENT: Quad/Graphics, Inc.

RECIPIENT PROJECT DIRECTOR: John Imes (414) 246-2080

STATE: Wisconsin

DOE REGION: V

CONGRESSIONAL DISTRICT: WI-9

CONGRESSIONAL REPRESENTATIVE: James Sensenbrenner (R)

SENATORS: Herb Kohl (D) Russel D. Feingold (D)

PROJECT NUMBER: 95-WI-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Div. of Energy and Intergov. Relations
Jolene Anderson (608) 266-7375

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1995

PROJECT SCOPE: Quad/Tech, Inc., a wholly owned subsidiary of Quad/Graphics, Inc., proposes to design, test, demonstrate, and commercialize a closed loop ink jet supply and printer solvent recovery system which will substantially reduce hazardous air pollutant emissions from ink jet printing in the magazine/publication, direct mail, product labeling/marking and packaging/container industries. Hazardous air pollutants include VOCs such as MEK, isopropyl alcohol, and methanol.

PROCESS DATA: 24.1 TONS OF RECYCLED VOCs

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	43×10^{10} Btu/yr/unit	14.9×10^{9} Btu/yr/unit	200×10^{12} Btu/yr
Environment (Waste Reduction)	3,330 tons/yr/unit	876 tons/yr/unit	1.7×10^{6} tons/yr
Economics (Annual Costs)	$5,584,500	$700,638	—

TECHNICAL PERFORMANCE

Ink Jet Supply and Printer and Solvent Recovery System

Background

Ink jet printing is one of the fastest growing segments of the printing and publishing industries, with annual growth exceeding 14%. This growth is tied to greater demographic targeting by publishers and marketers, who are interested in reaching their customers in a way that is more personable and flexible, while still remaining competitive with other forms of media.

Quad/Tech, Inc., a wholly owned subsidiary of Quad/Graphics, Inc., proposes to design, test, demonstrate, and commercialize a closed loop ink jet supply and printer solvent recovery system which will substantially reduce hazardous air pollutant emissions from ink jet printing in the magazine/publication, direct mail, product labeling/marking and packaging/container industries. Hazardous air pollutants include VOCs such as MEK, isopropyl alcohol, and methanol.

The proposed system provides a closed loop ink supply tank system which directs solvent vapors discharged from the tank through a vent tube connected to a condenser which cools the vapors sufficiently so that substantially all solvent vapor is condensed and returned via the tube to the ink supply tank. The system also includes a solvent supply container for containing solvent, a support device fro supporting the solvent supply container and a conduit connecting the solvent supply and make up solvent containers such that solvent can be supplied without venting it to the atmosphere.

Technical Progress / Project Status

Contract: Contract negotiations continue without any foreseeable problems. All contracts should be in place by February 1, 1996. Quad has commenced work on the project.

Commercialization: None to date.

Benefits: None to date.

Technical Transfer

To actively place this system into the marketplace, Quad will 1) complete technical testing of ink jet technology to verify performance (ink/solvent savings and recapture of fugitive emissions from printing process), 2) conduct market research to identify short and long term market opportunities for the ink jet technology, determine marketing objectives and strategies, 3) complete product development cycle by building a pilot run prototype of ink jet technology and testing in the manufacturing process, and 4) implement the marketing plan to get new ink jet product into the market.

The Quad system will be attractive because 1) it is less expensive both in capital and operational costs than conventional systems, 2) The Clean Air Act is stressing more source reduction and pollution prevention, and 3) there is little competition from other bindery control manufacturers. Potential buyers of the ink jet technology are expected to view the product more favorable because it has been developed by a company with a strong technical reputation.

Milestones

Milestone	Planned	Actual / Revised
Complete prod. testing of MEK prototype	10/95	
Release pilot run MEK prototype	4/96	
Complete preliminary market analysis study	7/96	
Complete initial analysis of 2nd MEK based system	10/96	
Release pilot run of 2nd system	1/98	
Set marketing plan	4/98	
Complete redesign of 2nd system	10/97	
Finalize full production systems - Project complete	7/98	

Budget and Cost Sharing

Funding Source	% Cost Share	Amount, $
DOE	11	425,000
State	0	0
Industry	89	3,600,000
Total	**100**	**4,025,000**

Points of Contact

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* POC for project description updates.

NICE^3 PROJECT DATA

Methanol Recovery from Hydrogen Peroxide Production

RECIPIENT: FMC Corp.

RECEPIENT PROJECT DIRECTOR: Mr. Thakkar (713) 474-8774

STATE: Texas

EPA / DOE REGION: VI

CONGRESSIONAL DISTRICT: 25

CONGRESSIONAL REPRESENTATIVE: Ken Bentsen (D)

SENATORS: Phil Grahm (R) Kay Hutchison (R)

PROJECT NUMBER: 91-TX-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4755

LEAD STATE AGENCY: Texas Water Commission
Jeff Voorhis (512) 475-2187

DOE SUPPORT OFFICE: Kurt Bohlman (214) 238-3178

FISCAL YEAR AWARDED: 1991

TECHNOLOGY IN USE: 1992

PROJECT SCOPE: Recover and reuse 90% of the methanol presently used to regenerate a hydrogen peroxide purification unit. This process will reduce the generation of hazardous waste (methanol) by 288,000 gallons per year, save 19.191 billion Btu per year and reduce operating expenses of this hydrogen peroxide manufacturing facility by $1,531,886 per year. This technology will be replicated at five other FMC plants and presented at industry conferences.

PROCESS DATA: ONE O-PROCESS SYSTEM (RECYCLING 1100 TONS OF METHANOL/YEAR)

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Savings	25.2×10^9 Btu/yr/unit	125×10^9 Btu	0.3×10^{12} Btu/yr
Environment (Waste Savings)	1100 tons/yr/unit	27,500 tons	14,205 tons/yr
Economics (Reduced Costs)	$512,000/yr/unit	$2,560,000	$2,286,000/yr

TECHNICAL PERFORMANCE

Methanol Recovery from Hydrogen Peroxide Production

Background

All hydrogen peroxide produced in North America is produced by the organic process (O-Process). In this process, quinones are carried in a recycling mixture of organic solvents known as work solution. The quinones are alternately reduced and oxidized to form hydrogen peroxide. The hydrogen peroxide is removed from the recycling work solution via a liquid-liquid extraction with deionized water. This resultant crude peroxide is purified and then concentrated in distillation columns up to the desired shipping concentration.

The process of purifying the crude hydrogen peroxide uses a catalyst to remove dissolved contaminants from the stream. Periodically, this catalyst must be regenerated to maintain its activity. One regeneration step for this catalyst involves a methanol wash and soak. After regeneration the methanol is contaminated with organic solvents, trace quantities of hydrogen peroxide, and metal cations. Prior to June 1991, the spent methanol was disposed of by burning in cement kilns as waste fuel. As of June 1991, new regulations impacting cement manufacturers have stopped the disposal of methanol in this manner. Methanol is now disposed of via incineration at a very high cost.

As a result of increasing methanol prices and rising disposal costs, recovery of methanol and reuse of spent methanol is being investigated by the FMC Corporation. Recovering the spent methanol by steam distillation will allow 90% of the volume of methanol now used to be recovered and reused to regenerate the purification catalyst. This is in line with FMC's 1989 commitment to reduce waste generation by 50%.

Technical Progress

The Methanol Recovery Process has been realizing benefits since 1992. FMC's methanol recovery efficiency is higher, (98%) than the original goal (90%). The final 1992 numbers were: 276,104 gallons of methanol recovered (502,080 gallons not sent off site for hazardous waste incineration), 25.169 Billion Btu of energy saved and $512,100 of economic savings at the plant. FMC plans to replicate the methanol recovery system at five additional FMC plants.

Commercialization: One unit in place at the FMC Pasadena Facility operating efficiently and realizing benefits since December 1992. One Unit in place at the FMC West Virgenia Facility Since January 1994.

Benefits: Aggregate energy savings: 125 x 10^9 Btu
Aggregate waste savings: 27,500 tons
Aggregate economic savings: $2,560,000

Milestones:

Milestone	Planned	Actual
Award	10/1/91	9/30/91
Approved equipment layout	11/3/91	10/28/91
Mechanical completion	12/25/91	2/28/92
Startup	2/20/92	3/2-7/92
Demonstration date	5/1/92	7/1-31/92
First operational report	5/1/92	4/29/92
Second operational report	8/1/92	7/10/92
Third operational report	11/1/92	10/23/92
Fourth operational report	3/10/93	3/10/93
Project Completion	7/23/93	7/23/93

Budget & Cost Sharing

Funding Source	%	Amount $
DOE/EPA	15.7	96,000
State	15.7	96,000
Industry	68.6	419,800
Total	**100**	**611,800**

Points of Contact:

* POC for project description updates.

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NICE^3 PROJECT DATA

Waste Water Recycle/Reuse: Water Based Paint

RECIPIENT:	PPG Industries Inc.	**PROJECT NUMBER:**	91-OH-1
RECIPIENT PROJECT DIRECTOR:	Maura Tinter (216) 671-7752	**HQ PROGRAM MANAGER:**	Alan Schroeder (202) 586-1641
STATE:	Ohio	**GO PROJECT MANAGER:**	Doug Hooker (303) 275-4780
EPA / DOE REGION:	V	**LEAD STATE AGENCY:**	Ohio Department of Development John Greenway (614) 466-7406
CONGRESSIONAL DISTRICT:	10	**DOE SUPPORT OFFICE:**	Juli Pollitt (312) 886-8571
CONGRESSIONAL REPRESENTATIVE:	Martin Hoke (R)	**FISCAL YEAR AWARDED:**	1991
SENATORS:	John Glenn (D) Mike DeWine (D)	**TECHNOLOGY IN USE:**	1993

PROJECT SCOPE: Clean paint rinse wastewater to the point where it can be reused. The water-based coating wastewater would be collected and routed to a non-thermal, non-vaporization physical separation system to recover the water from the paint wastewater. The reduced volume of waste is then collected for disposal. Additional studies will include an investigation of the reuse of the concentrated materials in the reduced volume of waste.

PROCESS DATA: 8 - 12 MILLION TONS OF AUTOMOTIVE PAINT/YEAR

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Use	4.4×10^9 Btu/yr/unit	13.2×10^9 Btu	66×10^9 Btu/yr
Environment (Waste Reduction)	4,479 tons/yr/unit	13,437 tons	67,000 tons/yr
Economics (Reduced Costs)	\$1.5 x 10^6/yr/unit	\$4.5 x 10^6	\$22.5 x 10^6/yr

TECHNICAL PERFORMANCE

Waste Water Recycle/Reuse: Water Based Paint

Background

PPG's Cleveland plant manufactures coatings for the automobile industry. Some products are water-based coatings, as opposed to solvent-based products. To ensure product quality, the processing equipment for the water-based products is frequently cleaned with water. This generates thousands of gallons of wastewater, which is disposed of as hazardous waste by transporting it to a state-licensed incinerator.

This project's goal is to clean paint rinse wastewater to the point where it can be reused. Currently the wastewater is shipped a substantial distance and disposed of as a hazardous waste. Modifications are required both to the treatment process and the paint cleaner system to incorporate the recycle process. The reclaimed water contains impurities at a low enough concentration that it can be reused. The impurities actually increase the cleaning effectiveness of the system. Therefore the water can be piped from the holding tank back to various manufacturing areas for reuse.

The water-based coating wastewater would be collected separately from the other wastes and routed to a new separation system. A non-thermal, non-vaporization physical separation system recovers the water from the paint wastewater. The recovered water is pumped to a holding tank. The recovered water still has some ketones and other impurities in low concentration, but this is actually a benefit because, based on preliminary tests, the recovered water cleans the equipment better. The reduced volume of waste is then collected for disposal. Additional studies will include an investigation of the reuse of the concentrated materials in the reduced volume of waste, along with optimum methods of treatment.

Technical Progress

The cationic Ultrafiltration/RO unit has processed 48 batches to date through 1993. Operation efficiency has steadied at 87% (avg.). Through 7/93 the plant has generated 395,000 gallons of waste water requiring disposal, down 86% compared with year to date 1992 figures. In addition, only 14,000 gallons of waste water have been discharged to the POTW as of 7/93.

Technical Transfer

The State of Ohio has distributed case studies of the installation to other companies interested in the technology. A pollution prevention brief has been worked up by the ODOD. PPG has disseminated the technology through two workshops which were conducted in the fall of 1994. It is estimated that national benefits are ten to twenty times the above estimates for one plant.

Commercialization: One unit in place at the Cleveland Facility operating efficiently and realizing benefits since January 1993.

Benefits: Aggregate energy savings: 13.2×10^9 Btu
Aggregate waste savings: 13,437 tons
Aggregate economic savings: $\$5.6 \times 10^6$

Milestones:

Milestone	Planned	Actual
Issued Ohio SECP	9/30/91	9/30/91
Ohio issued grant to PPG	10/30/91	10/30/91
Complete detailed design and project scope	12/31/91	1/92
Begin construction of short-delivery modifications to plant	1/15/92	2/92
Receive last of equipment	3/31/92	4/92
Complete construction	5/31/92	6/92
System checkout and startup	7/15/92	8/92
Evaluation of system complete	9/15/92	8/92
Send facility lab waste water to unit.	1/15/93	6/93
Ohio Regional Sewer District approval of waste water release	12/31/92	4/2/93
Grant complete	3/30/94	9/94
Final Report	3/30/94	12/1/93

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	50	227,000
State	0	0
PPG	47	227,000
Total	100	454,000

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* POC for project description updates.

NICE^3 PROJECT DATA

Electric Tundish

RECIPIENT:	AMPCO Metal	**PROJECT NUMBER:**	91-OH-1
RECIPIENT PROJECT DIRECTOR:	W. D. Nielsen, Jr. (216) 277-1226	**HQ PROGRAM MANAGER:**	Alan Schroeder (202) 586-1641
STATE:	Ohio	**GO PROJECT MANAGER:**	Doug Hooker (303) 275-4780
EPA / DOE REGION:	V	**LEAD STATE AGENCY:**	Ohio Department of Development John Greenway (614) 466-7406
CONGRESSIONAL DISTRICT:	13	**DOE SUPPORT OFFICE:**	Juli Pollitt (312) 886-8571
CONGRESSIONAL REPRESENTATIVE:	Sherrod Brown (D)	**FISCAL YEAR AWARDED:**	1992
SENATORS: John Glean (D)	Mike DeWine (R)	**TECHNOLOGY IN USE:**	1994

PROJECT SCOPE: A new system is proposed for heating the tundish by electric induction instead of fossil fuel. The proposed system will be 98% energy efficient and eliminate corrosive, polluting waste gases. The two principal innovations required to make the device feasible are the tapered diameter induction coil embedded in the refractory lining of the furnace and the shielding device which prevents induction of the support structure of the apparatus and the water jacket.

PROCESS DATA: ONE ELECTRIC TUNDISH

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Use	42 x 10^9 Btu/yr/unit	336 x 10^9 Btu	378 x 10^9 Btu/yr
Environment (Waste Reduction)	13,600 tons/yr/unit	108,800 tons	122,000 tons/yr
Economics (Reduced Costs)	\$1.8 x 10^6/yr/unit	\$14,400,000	\$16.2 x 10^6/yr

TECHNICAL PERFORMANCE

Electric Tundish

Background

This project addresses the continuous casting of barstock in certain copper alloys. A superheated reservoir of molten alloy is maintained in a continuously heated holding furnace (tundish) during casting. These tundishes are currently heated exclusively by fuel gas or oil, and are only 20% energy efficient. The proposed system will be 98% energy efficient and eliminate corrosive, polluting waste gases which cause porosity problems due to the entrapment of waste combustion gases in the casting. With reduced porosity, better quality parts can be more elegantly designed and downsized, reducing overall material and energy consumption.

The two principal innovations required to make the device feasible are the tapered diameter induction coil embedded in the refractory lining of the furnace and the shielding device which prevents induction of the support structure of the apparatus and the water jacket. With this process the problem of hydrogen gas entrainment in the molten bath, which occurs due to metal contact with combustion gasses, will be eliminated. The new technology will be targeted at foundries and continuous casting of barstock.

Technical Progress

The project is complete, proposed energy and waste benefits are being realized, and all four units have been operating successfully since 1994. Another NICE^3 success.

Technology Transfer

AMPCO presented the results of the benefits of the new technology at the U.S. EPA Industrial Energy Technology Conference in April 1994, Copper and Brass Servicenter Association Annual Meeting in April 1994, Non-Ferrous Founders Society Annual Meeting in October 1994, and Copper and Brass Fabricators Council Inc., Board of Directors Meeting in November 1994.

Articles were published in The Crucible Magazine in April 1994, The Foundry Magazine in June 1994, and the American Metal Market in June 1994. Personal visits will be made to key domestic industry members including Concast Metal products, Bunting Bronze Co., and Magnolia Metal Co. A customer oriented advertising campaign will focus on new products as well as the enhanced quality of the casting products. The improved waste reduction and energy savings resulting from the new technology will also be discussed.

Commercialization: Four units are in place at the Lorain Facility operating efficiently and realizing benefits December 1993.

Benefits: Aggregate energy savings: 336×10^9 Btu
Aggregate waste savings: 108,800 tons
Aggregate economic savings: $\$14.4 \times 10^6$

Milestones

Milestone	Planned	Actual/ Revised
Contract signed	12/1/92	3/8/93
Equipment Delivered	6/1/93	6/22/93
Equipment Installation	8/93	8/93
Equipment Startup	8/93	8/93
Order Placed for 3 Additional Units	8/93	8/93
Installation/Startup of Additional Units	10-11/93	12/93
Project/Grant Completion	1/31/94	8/94

Budget & Cost Sharing

Funding Source	%	Amount $
DOE/EPA	34.4	241,000
State	5.0	35,000
Industry	60.6	424,000
Total	100	700,000

Points of Contact

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NICE^3 PROJECT DATA

40% Recycled Paper

RECIPIENT: Damage Protection Products, Inc.

RECIPIENT PROJECT DIRECTOR: Harry Woods (707) 747-5503

STATE: California

EPA / DOE REGION: IX

CONGRESSIONAL DISTRICT: 7

CONGRESSIONAL REPRESENTATIVE: George Miller (D)

SENATORS: Diane Feinsteinr (D) Barbara Boxer (D)

PROJECT NUMBER: 92-CA-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Integ. Waste Mgmt. Board
Jim Robertson (916) 255-2409

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1992

TECHNOLOGY IN USE: 1994

PROJECT SCOPE: Produce an innovative paper product containing at least 40% post consumer mixed waste paper for the production of shipping pallets used for freight transport. This product will be equivalent in quality and production to products made with virgin fiber. Demonstrate a continuous production rate of 10 tons per day for 5 days. Share all marketing and production cost information concerning the project with the California Integrated Waste Management Board.

PROCESS DATA: 1.5 MILLION PALLETS /YEAR

E^3	Unit Savings	Cumulative Savings	Savings in Year 2010
Energy Use	540×10^9 BTU/yr/unit	2.03×10^{12} BTU	103.6×10^{12} Btu/yr
Environment (Waste Reduction)	65,000 tons/yr/unit	243,700 tons	12.6×10^6 tons/yr
Economics ($)	$350,000/yr/unit	$1,310,000	—

TECHNICAL PERFORMANCE

40% RECYCLED PAPER IN FREIGHT PALLET PRODUCTION

Background

In response to growing concerns about the amount of post consumer waste being generated, California has passed mandates to reduce this waste stream. Current focus of these efforts is on recycling paper. Many products incorporate various amounts of recycled paper content, while other products use only virgin material.

The paper industries in Japan, Korea, and Taiwan typically use up to 50% post consumer mixed paper waste (pcw) in a variety of paper products. In direct contrast, most U.S. paper product manufacturers are using virgin wood fiber.

This project will demonstrate how a typical paper product manufacturer can substitute raw material fiber requirements with 100% PCW with a 40% mixed waste (magazines, newspaper, and linerboard) content, with the resulting product being equivalent in quality and production to products made with virgin fiber.

Normal production of pallets is from 100% virgin corrugated paper. This project will demonstrate the use of post consumer mixed waste paper at a 40% substitution level.

Technical Progress

DPP has completed analyzing strength test data of the recycled paper pallets and turned in a final report to the California Integrated Waste Management Board (CIWMB) and the Department of Energy. Product and licenses have been sold domestically and abroad with the far east being the biggest market.

Technical Transfer

DPP has been selling the pallets and other dunnage materials domestically and abroad. They have also successfully licensed the technology for use in the far east to manufacture a variety of products including housing materials. The state has discussed transferring the technology to many idle paper producing plants in the inner city to stimulate job growth. DPP will share al info with the state which will aid in transferring the technology to a variety of applications.

Commercialization: One unit in place at the DPP Benicia Facility operating efficiently and realizing benefits for since march 1992. Liscenses have been sold abroad and will be difficult to track production.

Benefits: Aggregate energy savings: 2.03 trillion Btu (embodied energy of waste paper)
Aggregate waste savings: 243,700 tons post consumer mixed waste paper
Aggregate economic savings: $1,310,000

Milestones

Milestone	Planned	Actual / Revised
State Approval of CIWMB/DDP Contract	6/30/93	6/29/93
Paper Study, Phase I work	6/30/93	9/1/93
CIWMB approval of equip./process	6/30/93	7/30/93
94 Study Phase 2 Plan Due	7/20/93	7/30/95
Purchase equipment	8/12/93	8/1/93
40% PCW Product development/testing	9/93-2/94	9/1/93
Pilot Production of 40% PCW Corrugated	2/4/94	9/15/93
Final 40% PCW Production Shakedown	5/6/94	12/20/93
40% Demonstration of 10 tons/day - 5 days	6/13/94	4/94
Draft of Final Technical Report	7/10/94	9/94
Sales/shipment of 40% PCW pallets	6-8/94	7/94
Final Technical Report by DPP to DOE	9/9/94	1/95
Distribution of Final NICE^3 Report	9/30/94	5/95

Budget and Cost Sharing

Funding Source	%	Amount, $
DOE / EPA	21	100,000
State	30	142,906
Industry	49	238,521
Total	**100**	**481,427**

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Benicia, CA 94510
(707) 747-5503
(707) 747-5546 (fax)

* POC for project description updates.

NICE^3 PROJECT DATA

Ultrasonic Dishwashing

RECIPIENT: Ultrasonic Products, Inc.

RECIPIENT PROJECT DIRECTOR: David Evans
(805) 984-1817

STATE: California

EPA / DOE REGION: IX

CONGRESSIONAL DISTRICT: 23

CONGRESSIONAL REPRESENTATIVE: Elton Gallegly (R)

SENATORS: Diane Feinstein (D) Barbara Boxer (D)

PROJECT NUMBER: 92-CA-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: California Div. of Water Resources
Charlie Pike (916) 327-1649

DOE SUPPORT OFFICE: Julia Oliver (510) 637-1952

FISCAL YEAR AWARDED: 1992

TERMINATIOIN DATE: 1994

PROJECT SCOPE: Reduce the current dishwashing water temperature to 100° F through the use of ultrasonic cleaning. Eliminate the use of strong detergents, substantially reduce the use of water required for dishwashing, substantially reduce the effluent wastewater from dishwashing and achieve a reduction in dining ware breakage from thermal stress. The innovation developed by Ultrasonic Products, Inc. will use an omni-directional ultrasonic transducer molded into the geometry of the dishwasher.

PROCESS DATA: TECHNOLOGY REQUIRES FURTHER RESEARCH

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Use	TBD	TBD	TBD
Environment (Waste Reduction)	TBD	TBD	TBD
Economics (Reduced Costs)	TBD	TBD	TBD

TECHNICAL PERFORMANCE

Ultrasonic Dishwashing

Background

Current dishwashing technology was developed in the late 1800s. State of the art commercial washers are strikingly similar worldwide, and fundamentally use large volumes of high temperature water, pressure jetted with caustic chemicals to accomplish cleaning. Typically wash water temperature is 140-160 degrees F. and sanitizing rinse at 180 degrees° F.

In the fall of 1991, design and fabrication began on two ultrasonic washing systems; one for dining room ware, one for kitchen ware. The innovation developed by Ultrasonic Products, Inc. of Ventura, CA, utilizes an omni-directional ultrasonic transducer which can be molded into the geometry of the dishwashing unit. The new system is omnidirectional which allows waves to permeate into the interior of objects with no "dead spots". Much cooler water can be used because the cleaning action is derived from micro-bubbles that implode on the surface of the item to be cleaned at a rate of 40,000 times per second. Implosion creates the mechanical scrubbing and cleaning action.

Technical Progress

The grant period expired on September 30, 1994. UPI attempted to have the grant extended but did not meet the extension agreements established by the California Dept. of Water Resources resulting in termination of the grant. With regard to the NICE^3 grant, work is complete on the ultrasonic dishwashing unit. The unit operated at U. of California, Santa Barbara and the energy efficiency and water conservation goals for the unit were less than projected. Additional development of the unit is required before it will become a commercial commodity.

NICE^3 PROJECT DATA

Ultraviolet Curing: Pressure Sensitive Labels

RECIPIENT: Avery-Dennison
Fasson Films Div.

RECIPIENT PROJECT DIRECTOR: Donald McKee
(216) 639-3000

STATE: Ohio

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: 19

CONGRESSIONAL REPRESENTATIVE: Steve LaTourette (D)

SENATORS: John Glenn (D) Howard Metzenbaum (D)

PROJECT NUMBER: 92-OH-2

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Ohio Department of Development
John Greenway (614) 466-7406

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1992

TERMINATIOIN DATE: 1994

PROJECT SCOPE: Substitute the solvent-based process with an ultra-violet (UV) curing system in the manufacture of pressure-sensitive labels with silicone-coated paper or plastic release liners (backing material behind the peel-off mailing label). This process will utilize no solvents and reduce manufacturing costs. The UV light system is extremely small in comparison to the air oven and the curing response time is much quicker than the solvent system.

PROCESS DATA: PROJECT SELF-TERMINATED

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Use	TBD	TBD	TBD
Environment (Waste Reduction)	TBD	TBD	TBD
Economics (Reduced Costs)	TBD	TBD	TBD

TECHNICAL PERFORMANCE

Ultraviolet Curing: Pressure Sensitive Labels

Background

Avery-Dennison's Fasson Films Division (FFD) manufactures pressure-sensitive labels with silicone-coated paper or plastic release liners (backing material behind the peel-off mailing label). Currently, solvents are used for manufacturing silicone-coating release liners. The new process will substitute the solvent-based process with an ultra-violet (UV) curing system. This process will utilize no solvents and reduce manufacturing costs. UV is a 100% solids technology which results in no solvent emissions and significantly reduced manufacturing costs.

The current solvent system consists of a platinum catalyzed silicone polymer dissolved in solvent at a ratio of 5% solids to 95% solvent. This extremely low viscosity compound is applied with a direct gravure coater and is cured in a 100 foot to 125 foot air impingement oven.

The UV silicone system consists of a silicone polymer, antimony or acid-based catalyst, and a photo initiator. The resultant compound is 100% solids at approximately 400 centipoise viscosity. The system cures almost instantly when exposed to high intensity UV light.

Technical Progress

On January 6, 1994, Avery Dennison, parent company of Fasson Films, elected to terminate the contract. It appeared that the technology proved to be more successful than Avery Dennison originally planned and they were not interested in sharing the data.

NICE^3 PROJECT DATA

Closed Loop Solvent Recovery System

RECIPIENT:	The Lubrizol Corp.	PROJECT NUMBER:	93-TX-1
RECIPIENT PROJECT DIRECTOR:	Lynn Spain (713) 479-2851	HQ PROGRAM MANAGER:	Alan Schroeder (202) 586-1641
STATE:	Texas	GO PROJECT MANAGER:	Doug Hooker (303) 275-4780
EPA / DOE REGION:	VI	LEAD STATE AGENCY:	Texas Natural Resource Commission Jeff Voorhis 512-239-3178
CONGRESSIONAL DISTRICT:	TX-25	DOE SUPPORT OFFICE:	Kurt Bohlman (214) 767-7188
CONGRESSIONAL REPRESENTATIVE:	Ken Bentsen (D)	FISCAL YEAR AWARDED:	1993
SENATORS: Phil Gramm (R)	Kay Hutchinson (R)	SELF-TERMINATED:	1994

PROJECT SCOPE: Evaluate the use of a closed loop propane/butane based solvent extraction system to recover organic material, for reuse/recycle, contained in filtration media currently disposed off-site. Produce filter cakes, with no hazardous or non-hazardous organic content, than can be disposed of in an appropriate landfill. In many cases it is anticipated that, once the organic has been removed, the solids in the cake can be returned for reuse. Recover and reuse the valuable organic cakes.

PROCESS DATA: PROJECT SELF-TERMINATED

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Use	TBD	TBD	TBD
Environment (Waste Reduction)	TBD	TBD	TBD
Economics (Reduced Costs)	TBD	TBD	TBD

TECHNICAL PERFORMANCE

A Closed Loop Propane/Butane Solvent Recovery System

Background

Lubrizol is evaluating the feasibility of using a closed loop propane/butane based solvent extraction system to recover organic material, for reuse/recycle, contained in filtration media currently disposed off-site. Additionally, this project may treat waste oil/water streams to a level permitting reuse/recycle. The primary materials that will be affected are filtration media, centrifuge sludge and waste oils. This system is a processing step which receives a product stream and produces both a product material and a waste which is significantly lower in hazardous constituents.

This project has as its goal the production of filter cakes, with no hazardous or non-hazardous organic content, than can be disposed of in an appropriate landfill. In many cases it is anticipated that, once the organic has been removed, the solids in the cake can be returned for reuse. This would provide a system that recovers all the valuable organic from the cakes and produces a solids product that can be reused or used to replace alternate feed materials. Thus, there is a significant possibility of eliminating the need to dispose of the current solids stream in any way.

Technical Progress

The grant was self-terminated by Lubrizol in 1994. The reason is not completely clear but it appears that a regional branch of Lubrizol may have been conducting business without the understanding of the corporate office. The official reason for grant termination is that Lubrizol does not conduct business with the government.

NICE^3 PROJECT DATA

Ultrasonic Tank Cleaning: Pharmaceutical Industry

RECIPIENT: DuPont-Merck

RECIPIENT PROJECT DIRECTOR: Angelo Piro
(609) 540-4827

STATE: New Jersey

EPA / DOE REGION: II

CONGRESSIONAL DISTRICT: NJ-2

CONGRESSIONAL REPRESENTATIVE: F. LoBiondo (R)

SENATORS: Bill Bradley (D) Frank Lautenberg (D)

PROJECT NUMBER: 92-NJ-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: NJ Dept. of Energy & Env. Protection
Sid Palius (609) 984-3729

DOE SUPPORT OFFICE: Kathryn Humphrey (212) 264-1239

FISCAL YEAR AWARDED: 1992

TECHNOLOGY IN USE: 1994

PROJECT SCOPE: Use a tubular resonator to allow homogenous, radial omni-directional sound distribution (ultrasound) for the purpose of tank cleaning. Eliminate the use of solvents used in conventional tank cleaning along with the emission of volatile organic compounds (VOC) derived from the cleaning and disposal process of the spent solvent. Reduce overall time and energy consumption for the tank cleaning process.

PROCESS DATA: ONE TANK CLEANING DEVICE

E^3	Unit Savings	Cummulative Savings	Savings in Year 2010
Energy Use	3.62×10^9 Btu/yr/unit	52.5×10^9 Btu	2.0×10^{12} Btu/yr
Environment (Waste Reduction)	8.8 tons/yr/unit	127 tons	4840 tons/yr
Economics (Payback)	$156,000/yr/unit	$2,262,000	$85,000,000/yr

TECHNICAL PERFORMANCE

Ultrasonic Tank Cleaning: Pharmaceutical Industry

Background

Chemical and pharmaceutical companies in the United States have long used solvents to clean tanks. Conventional cleaning techniques depend on solubility or emulsification of a contaminant in a solvent to clean. Cleaning with these solvents results in the emission of volatile organic compounds (VOC) from the cleaning process and from incineration or other disposal of the spent solvent.

Ultrasonic cleaning with water has been the standard for cleaning small laboratory glassware where removal of both chemical, biological and insoluble particulate contaminants is critical. The key reason for the exclusion of ultrasonics in large scale applications is that most ultrasonic transducers produce an energy wave that is uni-directional, that is, propagating in only a single direction. Even when using a cluster of uni-directional ultrasonic transducers, "dead spots" can form.

TELSONIC AG (Bronschhofen, Switzerland) has developed a tubular resonator which allows homogenous, radial omni-directional sound distribution, minimizing "dead spots." The development of this tubular resonator also makes possible the internal cleaning of tanks and containers through a small opening. With the high costs of energy, solvents and waste disposal, water-based ultrasonic cleaning becomes an attractive alternative to conventional solvent based cleaning.

Technical Progress

Technical transfer seminars were held on May 10 and May 23. The New Jersey Institute of Technology notified over one thousand companies about these meetings. Attendance at the two seminars totaled approximately 30 people. The principal investigator for DuPont-Merck has left the company to work for the ultrasonic supplier.

DOE personnel attended a tech transfer seminar sponsored by DuPont-Merck and NJ Inst. of Tech. in NJ. The project is essentially complete. The technology has been successfully demonstrated at DuPont-Merck and several units are in place and realizing benefits. The technology has been transferred to DuPont Paint and PPG Industries. This will be the last report.

Milestones

Milestone	Planned	Actual/ Revised
First equipment arrives	3/15/93	3/7/93
Contract signed by NJDEPE and industry	3/93	5/94
Begin ultrasonic testing	4/93	4/93
Begin construction of explosion-proof cabinets	10/93	10/93
Complete construction of explosion-proof cabinets	5/94	3/94
Grant period ends - Project complete.	6/95	6/95

Technical Transfer

The New Jersey Department of Environmental Protection and Energy (DEPE) will develop a Memorandum of Understanding with the New Jersey Institute of Technology (NJIT) Technical Assistance Program to market and disseminate information to the private sector. This entity will develop a brochure and technical information sheet and will hold two workshops, one for the chemical industry and one for the pharmaceutical industry to discuss applications of the technology and results of the demonstration. DEPE's Office of Energy will prepare an evaluation of the entire project.

Commercialization: The technology has been transferred as follows: one unit was put in place at DuPont in the paint research division in June 1993 and one unit has been in place since 1994 January at PPG. DuPont-Merck has had four units in place since March 1993. Currently, three companies are analyzing the ultrasonic tank cleaning unit.

Benefits: Aggregate energy savings: 896 billion Btu (electricity)
14.0 billion Btu (embodied energy of methanol)
Aggregate waste savings: 35.2 tons of methanol

Aggregate economic savings: $1,172,000

Budget & Cost Sharing

Funding Source	%	Amount, $
DOE/EPA	40	399,004
State	22	230,268
Industry	37	377,672
Total	100	1,006,944

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NICE^3 PROJECT DATA

SPENT POTLINER RECYCLING: ALUMINUM PRODUCTION

RECIPIENT:	Columbia Aluminum Corp.	PROJECT NUMBER:	93-WA-1
RECIPIENT PROJECT DIRECTOR:	Wayne Wooster 509-773-7222	HQ PROGRAM MANAGER:	Alan Schroeder (202) 586-1641
STATE:	Washington	GO PROJECT MANAGER:	Doug Hooker (303) 275-4780
EPA / DOE REGION:	X	LEAD STATE AGENCY:	Washington Dept. of Ecology Tamie Kellog (206) 407-6741
CONGRESSIONAL DISTRICT:	WA-4	DOE SUPPORT OFFICE:	Roxanne Dempsey (206) 553-2155
CONGRESSIONAL REPRESENTATIVE:	Richard Hastings (R)	FISCAL YEAR AWARDED:	1993
SENATORS: Slade Gorton (R)	Patty Murray (D)	SELF-TERMINATED:	1995

PROJECT SCOPE: Utilize a Spent Potliner (SPL) plasma recycling process that incorporates the plasma torch operation (first developed during the early years of the space program) and the process of aluminum reduction. Application of the SPL recycling process will assess the recycled and marketable products resulting from the SPL plasma recycling process, improve efficiency and lower energy use, refine the brick materials production process, and test market the SPL recycling process and recycled products.

PROCESS DATA: PROJECT SELF-TERMINATED

E^3	Unit Savings	Cumulative Savings	Savings in 2010
Energy Use	TBD	TBD	TBD
Environment (Waste Reduction)	TBD	TBD	TBD
Economics (Reduced Costs)	TBD	TBD	TBD

TECHNICAL PERFORMANCE

SPENT POTLINER RECYCLING: ALUMINUM PRODUCTION

Background

One of the nations's most energy intensive industries, the aluminum industry, must rapidly and economically resolve a major national environmental problem: how to dispose of and/or recycle spent potliner (SPL), a listed hazardous waste.

Aluminum is produced by the electrolytic reduction of alumina in a bath of cryolites in large, reinforced steel shells, referred to as cells or "pots." The cathode of these pots is lined along the sides and bottom with insulating brick. On this lining (or "potliner"), carbon blocks and rammed carbon paste are layered to provide high electrical conductivity and resistance to corrosion by molten aluminum. The infiltrations, temperature variations and chemical reactions cause internal stresses which gradually deteriorate the inside lining.

Under current hazardous waste regulations, SPL is designated hazardous due to its cyanide and fluoride content. The U.S. Environmental Protection Agency (EPA) anticipates that regulations will be promulgated that prohibit land disposal after mid-1995.

The goal of the project is to utilize a SPL plasma recycling process that incorporates the plasma torch operation (first developed during the early years of the space program) and the process of aluminum reduction. Columbia Aluminum Corp. plans to move beyond the basic application of the SPL recycling process to achieve the following: 1) make more detailed assessments of the recycled and marketable products that result from using the SPL plasma recycling process; 2) examine a range of process parameters to improve efficiency and to lower energy use beyond what is estimated by this proposal while maintaining satisfactory environmental and recycling product standards; 3) develop and refine the ability to produce brick materials that can be used in the potliners or applied to other beneficial uses; and 4) test market the SPL plasma recycling process and recycled products.

Technical Progress

The grant was awarded in 1993 and after two years of disputes over intellectual property and a potential regulatory classification of the plasma arc system as an incinerator, Columbia self-terminated the grant. There was no official statement from Columbia on the termination, but if the system was classified as an incinerator, there would have been regulatory problems with testing the system since Washington is not granting permits for new incinerators.

NICE^3 PROJECT DATA

Advanced Tooling Technology for Plastic Molding

RECIPIENT: Techmetals Inc.

RECIPIENT PROJECT DIRECTOR: Paul Newsad (513) 253-5311

STATE: Ohio

EPA / DOE REGION: V

CONGRESSIONAL DISTRICT: OH-3

CONGRESSIONAL REPRESENTATIVE: Tony Hall (D)

SENATORS: John Glenn (D) Mike DeWine (R)

PROJECT NUMBER: 94-OH-3

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Bill Ives (303) 275-4755

LEAD STATE AGENCY: Ohio Dept. of Development
Ruth Gonser (614) 466-1868

DOE SUPPORT OFFICE: Juli Pollitt (312) 886-8571

FISCAL YEAR AWARDED: 1994

SELF-TERMINATED: 1995

PROJECT SCOPE: The proposal focuses on the application of an engineered insulating layer onto the surface of molds used for injection molding of plastics. The use of a cooled mold surface allows for enhance flow along the surface and improved surface appearance. The improved surface appearance directly out of the mold allows for a significant reduction in the number of process steps that following molding. A reduction in steps translates into lower cost, lower energy consumption and a reduction in wastes.

PROCESS DATA

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	7.17 x 10^9 Btu /yr / mold unit	3.58 x 10^9 Btu /yr / mold unit	19.73 x 10^{12} Btu/yr
Environment (Waste Reduction)	3663 tons/ yr/ mold unit	1257 tons/year/mold unit	3.84 x 10^6 tons/yr
Economics (payback)	- - -	1 yrs.	—

TECHNICAL PERFORMANCE

Advanced Tooling Technology for Plastic Molding

Background

Plastic molded parts requiring consistent and high luster finishes demand large amounts of post finishing operations, leading to long production cycles, costly manufacturing, assorted waste and environmental concerns. TEMIS, an advanced plastic molding technology in which the inner surface of the mold is coated with a thin thermal insulator provides solutions to all of these manufacturing bottlenecks. The process provides a ready to use surface, as molded, that eliminates costly post finishing operations, increases manufacturing productivity, reduces stress in the molded part to improve part performance, and eliminates waste generated in post finishing operations such as polishing, sanding, filling and painting.

The goals of the technology center around eliminating the costly post treatment processes required to obtain a smooth consistent finish, on molded components, that can be painted or plated to obtain the final finish. Currently this technology has been used only in the plastic molding industry, but due to its specific application capability it has the potential to aid in the composite industry.

Techmetals will work with General Electric Plastics, Hewlett Packard, and The Edison Materials Technology Center to develop the technology by designing tool changes and machine modifications and then begin mold testing. The results will be evaluated and be made available throughout the industry.

Technical Progress

The grant was awarded in 1994 and terminated in 1995 by Techmetals after they lost the support of one of their major cost sharing partners.

NICE^3 PROJECT DATA

VOC Control Strategies: Minimization and Recovery Technologies

RECIPIENT: MTI / Pajco

RECIPIENT PROJECT DIRECTOR: Bob Rose
(518) 785-2211

STATE: New York

EPA / DOE REGION: II

CONGRESSIONAL DISTRICT: 21/25

CONGRESSIONAL REPRESENTATIVE: McNulty(D) 21
Walsh(R) 25

SENATORS: Daniel Moynihan (D) Alfonse D'Amato (R)

PROJECT NUMBER: 91-NY-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: NYSERDA
Adele Ferranti (518) 432-6251 x206

DOE SUPPORT OFFICE: Kathryn Humphrey (212) 264-1239

FISCAL YEAR AWARDED: 1991

TECHNOLOGY REQUIES FURTHER DEVELOPMENT 1995

PROJECT SCOPE: Develop and transfer an innovative approach for VOC minimization and recovery technologies. An energy efficient solvent condensing system will be designed and demonstrated for small businesses and small applications. The project will train technical personnel (government and industry) on the usefulness of the VOC screening model and VOC software for their particular applications.

PROCESS DATA : 276,000 lbs. of Solvent/yr. Recovered

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	26.8×10^9 Btu/yr	$-.00676 \times 10^{12}$ Btu/yr/unit	34×10^{12} Btu/yr
Environment (Waste Reduction)	138 tons/yr/unit	0	138,000 tons/yr
Economics (Annual savings)	----	$157,679/yr	361×10^6/yr

TECHNICAL PERFORMANCE

VOC Control Strategies: Recycle and Recover Technologies

Background

Many industries, including printing, chemicals, pharmaceutical, metal cleaning, laundries, photographic supplies, and others rely on the use of solvents at intermediate points in their production process. In many processes, the solvent ends its cycle as a vapor contaminant in a warm air stream. Due to environmental and public health issues manufacturers have been left with three choices: (1) eliminate or modify organic and halo-organic solvent use in the process; (2) incinerate solvents before release; or (3) recover and recycle solvents from the solvent laden air.

The purpose of this project is to develop and transfer an innovative approach for VOC minimization and recovery technologies. Under this project, an energy efficient solvent condensing system will be demonstrated designed for small businesses and small applications. The project will also involve training technical personnel (government and industry) in the use of a VOC screening model and a survey of participants on the usefulness of the VOC software for their particular applications.

Technical Progress

MTI and Pajco installed the demo unit for the site visit in August, 1995. The demo unit was in place by early August and testing took place during the following two weeks. On August 22, 1995 MACTEC/GO personnel conducted a site visit at the Pajco Products facility in Lowville, NY which was attended by state and industry personnel. Regional DOE personnel were unable to attend. The VOC Recovery System was demonstrated and then dismantled. The future of the project was discussed. The project is essentially complete with regard to the NICE^3 grant.

NICE^3 PROJECT DATA

Fiberglass Resin Overspray and Sander Dust Reclamation and Panel Production System

RECIPIENT: TRON Co.

RECIPIENT PROJECT DIRECTOR: Ron Powley (503)882-5408

STATE: Oregon

EPA / DOE REGION: X

CONGRESSIONAL DISTRICT: OR-2

CONGRESSIONAL REPRESENTATIVE: Wes Cooley (R)

SENATORS: Mark Hatfield (R) Bob Packwood (R)

PROJECT NUMBER: 93-OR-1

HQ PROGRAM MANAGER: Alan Schroeder (202) 586-1641

GO PROJECT MANAGER: Doug Hooker (303) 275-4780

LEAD STATE AGENCY: Oregon Dept. of Energy
Mark Kendall (503) 378-8444

DOE SUPPORT OFFICE: Roxanne Dempsey (206) 553-2155

FISCAL YEAR AWARDED: 1993

DECLINED GRANT AWARD 1995

PROJECT SCOPE: Develop a small-scale successful HCl recovery system ($200,000 range for the smallest unit). This system will be a closed-loop, cost-effective method available for on-site recovery needs of galvanizers and small- to medium-sized steel manufacturers. This system is based on Beta's proprietary design and engineering techniques, incorporating recent advancements in materials technology and automated controls. System introduction into the marketplace will follow.

PROCESS DATA: 125 TONS OF RECYCLED HCl / YEAR

E^3	Current Technology	Proposed Technology	Savings in Year 2010
Energy Use	8,288 x 10^6 Btu/yr/unit	3,000 Btu/yr/unit	522 x 10^9 Bru/yr
Environment (Waste Reduction)	200.5 tons/yr/unit	0.5 tons/yr/unit	42,000 tons/yr
Economics (Payback)	----	1.4 yr	----

TECHNICAL PERFORMANCE

Fiberglass Resin Overspray and Sander Dust Reclamation and Panel Production System

Background

The TRON Company is working with AquaGlass, the largest manufacturer of fiberglass bathtubs, to develop a production capacity process to reintroduce fiberglass manufacturing and wood product waste into the manufacture of fiberglass bath tubs and showers. The AquaGlass facility in Klamath Falls, Oregon will host the demonstration project and is the largest facility of it's kind in the Pacific Northwest. Production waste from spraying fiberglass resin, trimming fiberglass products and sanding finished wood products will become feedstocks for the manufacture of structural boards. The new fiberboard will be used to provide structural rigidity for bathtubs, showers an other fiberglass products. It replaces an all wood chip pressed board.

The process developed by the TRON Company blends the waste products in a custom vat with a resin binder, transports the material to a panel press to heat form a structural board that is reused in the bath tub manufacturing process. The equipment is custom designed for this application and will shred fiberglass over spray, resin clogged filters and trim waste to a fibrous consistency and blend it with the sander dust. The blended material is mixed with a proprietary resin binder and pressed under high pressures and temperatures to produce a strong fiberboard product. The equipment to transport blended material, panel presses and mold ejectors are specifically designed for this application. The current prototype has been tested and the technology proven the feasible.

Principle innovations include the blending, material handling and molding processes. The innovations include the characteristics of the binding agent, the equipment used to blend the fiberglass and sander dust, material transportation systems, molds, panel press adaptation and mold release technology. Also unique to this project will be the electrical, pneumatic and mechanical automation controls.

Technical Progress

TRON Co. declined the award in May 1995 after one of their cost-sharing partners dropped out of the project.

Q362. Page 503 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the Climate Wise Program:

	2000	2010	2020
Energy Savings (quads)	**.149**	**.331**	**0.513**
Energy Cost Savings ($billions)	**.6**	**1.5**	**2.3**
Carbon Savings (MMTCE)	**3.0**	**6.5**	**10.0**

Q362a. Please provide detailed documentation of these claims, including the peer review process undertaken.

A362a. To calculate projected energy and cost savings, and CO_2 emissions reductions in future years we used a model which estimates the program's likely success in recruiting companies and the subsequent impacts of projects undertaken by those companies. This methodology involves calculating actual and projected participation of Climate Wise companies and estimating the effects of energy efficiency and pollution prevention activities resulting from their participation in the Climate Wise Program. To do this, we combined information on likely Climate Wise Program participation patterns with data on industry employment, energy use, and energy savings to come up with a conservative estimate of the energy efficiency impact of the Climate Wise Program. To project future impacts, we used an estimation approach that captures what is known about current partners and projects future participants based on current implementation plans and ongoing activities. The analytic approach to estimating the energy efficiency and pollution prevention impacts of the Climate Wise Program relied on the broad framework illustrated in Exhibit 1.

Exhibit 1
Framework for Estimating Carbon Reductions Attributable to Climate Wise
(1996 - 2000)

Energy Use of Participant (Quads) = #Participant Finns * #Employees per Firm * Energy Use per Employee

Energy Savings (Quads) = Energy Use of Participants (Quads) * Energy Reduction (%)

Carbon Reductions (tonnes)=Energy Savings (Quads) * Carbon emissions rate (tonnes/Quad)

All energy use, savings, and carbon reduction calculations were performed at a disaggregate level and aggregated to produce the reported results. Estimates of average firm size applicable to each recruiting program, and energy usage per employee and energy savings estimates for specific industries were used. Specific assumptions are described below.

- *Industry Groups.* For each partner set (existing partners; state, local and regional level activities; and each of the National-focused programs), specific assumptions were made regarding the distribution of firms across the manufacturing Standard Industrial Classifications (SIC) codes. In deriving energy and carbon impacts for existing partners, we used information on their industry distribution.

The placement of future National partners by SIC code was based upon targets by recruiting thrust. When a recruiting effort does not target a specific industry sector (such as programs that are focused instead on partnering with state and local governments), general assumptions on size and energy usage characteristics were used.

In the post-2000 period, no detailed assumptions are made regarding the industrial representation of Climate Wise Participants. To simplify the approach we assume that the program recruits new companies which represent a share of U.S. industrial energy use.

- *Average Size.* Under the analytic framework, energy use depends on average firm size (i.e., number of employees per firm within a specific SIC code). Therefore, explicit assumptions regarding the number of employees in current and future Climate Wise companies are necessary and reflect the types of companies that will be targeted in each program. These detailed assumptions regarding firm size were used in estimating program impacts in the 1996 through 2000 period. Beyond this time, a simpler, aggregate approach was used and no specific assumptions regarding firm size was made.

- *Energy Use.* We estimated energy use for Climate Wise participants based upon (1) the projected number of firms participating, (2) the average firm size as measured by the number of employees, and (3) an estimate of energy consumption per employee. Energy consumption per employee was based on the 1991 Manufacturing Energy Survey (MECS 1991) and reflected energy usage at manufacturing facilities. Summing across all participants in each year and industry group provides the total energy consumption of Climate Wise participants. After 2000, the Climate Wise participation assumptions were simplified due to limited long-term information. Rather than attempting to calculate energy use per company, we developed projections of the share of U.S. industrial energy use that new and existing Climate Wise companies will represent.

- *Energy Savings Estimates.* Estimates of energy savings achieved by Climate Wise participants in the 1996 through 2000 period were based on two sources: (1) the experience of an industrial energy audit program conducted over the last two decades under the auspices of the DOE Energy Analysis and Diagnostic Center/Industrial Assessment Center (EADC/IAC) program, and (2) a review of the literature on the potential for energy efficiency gains in industry. First-year energy savings were based on EADC/IAC data, and subsequent-year savings trend towards the long-term average industrial energy savings potential, as reported in recent studies.

  Estimates of energy savings for each major manufacturing sector (as determined by SIC code) were derived from the EADC/IAC database after adjusting its results to avoid potential overlap with CCAP and other ongoing programs, specifically Motor Challenge, Green Lights, Energy Star Buildings and Computers, Rebuild America, NICE-3, and others. Energy savings associated with the remaining actions were used as the basis for the estimates of the impacts of unique aspects of Climate Wise. These measures include boiler maintenance and improvement programs, thermal system measures, and operations changes and improvements.

- *Carbon Reductions.* Carbon reductions in all years were simply calculated as the product of energy savings for all partners and a carbon coefficient (from AE096 and IDEAS runs for the Biennial CCAP Review) in metric tons (tonnes) per unit of energy reduced for each year in which reductions occur.

- *Cost Savings.* Cost savings were based on estimated annual energy savings (in MMBtu) achieved by participants in each year and an estimate of the average industrial energy price (in $/MMBtu) weighted to reflect the expected types of fuel saved.

Q362b. Please document why these benefits would not occur in the absence of DOE funding.

A362b. As part of the calculation of Climate Wise Program benefits an estimate of baseline improvements in energy savings which would occur without Climate Wise involvement was calculated using SIC-specific energy savings estimates from the EADC/IAC database. Baseline reductions in energy intensity averaging 1.2 percent per year were based on the biennial CCAP Review. The resulting net energy savings is interpreted as the incremental first-year energy reductions achievable to firms over estimated baseline efficiency improvements which would occur without program participation.

Q363. Page 506 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following Climate Wise performance metrics for FY 1995 and FY 1996:

Measure:

	1995	1996
Cumulative Partners	40	267
Incremental Partners	40	200
% of U.S. Indust. use rep.	6	8.4
Annual energy savings	--	.0133

Please provide detailed documentation for each of these claimed performance metrics in FY 1995 and FY 1996, including identification of each "Partner", and DOE funding provided to each such partner in FY 1995 and FY 1996.

A363. Climate Wise partners as of 1995 fiscal year end were: DuPont, AT&T, Weyerhaeuser, Lockheed Martin, Georgia Pacific Corporation, Johnson & Johnson, Fetzer Vineyards, ETTA Industries, Inc., Majestic Metals, Coors Brewing Company, General Motors Corporation, Pacific Coast Producers, Quad/Graphics, Inc., DOW Chemical Company, DeBourgh Manufacturing Company, Rocky Mountain Embossing & U.S. Foil Printing, Weaver Potato Chip Co., Inc., SAE Circuits, The Longfellow Clubs, Micropyretics Heaters International, Ohmeda, Behlen

Manufacturing Corp., Graham Contracting, Louis Allis Company, Metal Arts Company, MBA Polymers, Louisiana-Pacific Corporation, Hamilton County Business Incubator, Solar Turbines, Pacific Clay Products, Midwest Research Institute, Tri Valley Growers, Samsonite Corporation, Erving Paper Mills, Liquid Sugars, Inc., Saint Barnabas Medical Center, Central Products Co.-Brighton, CF&I Steel, L.P., Lindsay Mfg., Co., and Maui Pineapple Company, Ltd.

None of these companies receives funding from the Climate Wise program. Climate Wise is a voluntary program that provides no funding for projects undertaken by participating companies. Companies choose to invest in energy efficiency and pollution prevention projects within the program based upon their value to them. Once they can identify appropriate projects, companies often find that they offer returns competitive with alternate uses of their available investment capital.

Estimates of partners for 1996 reflect planned recruiting activities as described above in response to question 362.

Estimates of the percentage of U.S. industrial energy usage is based on an estimation methodology described above in response to question 362.

Energy savings estimates for 1995 and 1996 are based on the methodology described above in response to question 362.

Q364. Please provide a listing of the recipients of (i) the $2,409,000 in funding in FY 1995, (ii) the $1,952,000 in FY 1996 funding, and (iii) the requested level of $3,400,000 in FY 1997 for Climate Wise.

A364i. FY 1995
American Institute for Pollution Prevention
Los Alamos National Laboratory
National Renewable Energy Laboratory
Pacific Northwest National Laboratory
Sandia National Laboratories
Business for Social Responsibility Education Fund
States of Nebraska, North Carolina, Ohio, Oregon, Pennsylvania, and Wisconsin

A364ii. FY 1996 funding was provided under the conditions of several continuing resolutions until the recent completion of the FY 1996 budget agreement affecting the Climate Wise program. Thus, the following is a current, but not final, list of recipients of these funds: Argonne National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories, various states (to be determined)

A364iii. No FY 1997 funding has been received. Planning for the disbursement of funds requested for FY 1997 is ongoing, but determination of specific recipients will depend upon a number of factors including level of funding, performance of past recipients, and program results.

Q365. For each recipient of Climate Wise funds identified in the response to question 364 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A365i. FY 1995

American Institute for Pollution Prevention–no cost share
Los Alamos National Laboratory–no cost share
National Renewable Energy Laboratory–no cost share
Pacific Northwest National Laboratory–no cost share
Sandia National Laboratories–no cost share
Business for Social Responsibility Education Fund–50% cost share
States of Nebraska, North Carolina, Ohio, Oregon, Pennsylvania, and Wisconsin–100% cost share

A365ii. FY 1996

Argonne National Laboratory–no cost share
National Renewable Energy Laboratory–no cost share
Oak Ridge National Laboratory–no cost share
Pacific Northwest National Laboratory–no cost share
Sandia National Laboratories–no cost share
Various states (to be determined) –100% cost share likely

A365iii. FY 1997

Not applicable.

Q366. For those Climate Wise funding recipients identified in the response to question 364 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A366i. FY 1996

American Institute for Pollution Prevention–Grant awarded for an unsolicited application which, upon review, was found to be meritorious, and represented a unique approach to deploying technology.

As indicated in question 364 above, the Climate Wise Program provided funding to several *DOE* National Laboratories for the purpose of working with industrial partners. Laboratories submit Field Work Proposals annually to the Office of Industrial Technologies. The process of funding on the basis of Field Work Proposals is non-competitive, in accordance with Departmental regulations.

Business for Social Responsibility Education Fund–Cooperative Agreement was found to offer a unique approach to deploying Climate Wise program in partnership with this organization's existing program of activities.

States of Nebraska, North Carolina, Ohio, Oregon, Pennsylvania, and Wisconsin–Each of these states offered a combination of qualifications of personnel, uniquely suited existing programs, and leadership in industrial pollution prevention and energy efficiency initiatives.

A366ii. FY 1996

As indicated in question 364 above, the Climate Wise Program provided funding to several DOE National Laboratories for the purpose of working with industrial partners. Laboratories submit Field Work Proposals annually to the Office of Industrial Technologies. The process of funding on the basis of Field Work Proposals is non-competitive, in accordance with Departmental regulations.

Various states (to be determined) --Will be done on a competitive basis.

A366iii . FY 1997

Not applicable.

Q367. Page 503 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for quantifiable benefits of the Inventions and Innovations Program:

	2000	2010	2020
Energy Savings (quads)	.070	.094	0.094
Energy Cost Savings ($billions)	.16	.22	.22
Carbon Savings (MMTCE)	1.69	2.242	2.225

Q367a. Please provide detailed documentation of each of these claimed benefits.

A367a. Current and projected energy savings are based on data collected from funded technologies by a biennial program evaluation conducted by the Oak Ridge National Laboratory (Braid, Robert B., Jr., et al, January 1996 draft, The Energy-Related Inventions Program: A Continuation of Demonstrated Benefits to the Inventor Community; Oak Ridge, Tennessee, Oak Ridge National Laboratory, ORNL/CON-429.) The evaluation involves mailing questionnaires to all participants in the Energy-Related Inventions Program (ERIP). However, energy savings in quads and dollars and the carbon savings are based specifically on the actual energy saved by inventions that have entered the marketplace. The data collected by Oak Ridge National Laboratory are used to determine the types and amounts of fuel displaced, which is then converted to quads as a common unit of energy savings. The value of the energy savings is calculated by multiplying the amount of fuel displaced by the value of the fuel. Carbon savings are calculated using an EIA-developed conversion factor for each of the fuel types displaced.

Q367b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A367b. In their evaluation, Oak Ridge National Laboratory compared ERIP participants' success against that of a comparison group. The comparison group earned the same technical evaluation ratings (uniqueness, technical feasibility, and commercial competitiveness) as the ERIP participants but did not seem to have sufficient energy benefits for program participation. Members of the comparison group were referred to their local Small Business Development Centers for further assistance instead of being recommended to DOE. The key findings were:

- Average dollar sales by ERIP participants are an order of magnitude greater than the comparison group.

- Only 6 percent of the comparison group referrals were associated with employment in recent years, compared with 58 percent of the ERIP participants.

The ORNL study concludes: "These results provide strong evidence that ERIP-supported technologies achieved their considerable commercial success, at least in part because of the support provided by the Energy-Related Inventions Program."

Furthermore, there is much evidence that these technologies from independent inventors and small companies would not have been successful without Government support. One example is that less than 1 percent of all venture capital in this country is used for energy-related technologies.[1] This shortage of capital means that energy-related technologies created by this clientele have to struggle to find other sources of funding, and they are forced to seek it from Government programs (such as this one or the Small Business Innovation Research Program), friends, family, "angel" investors, and on rare occasions banks.

Lastly, inventors supported by this program have frequently stated that they were out of money when the ERIP grant arrived, and it arrived at a critical time in the development of their technology. The technical evaluation coupled with the grant offered by this program also provide needed credibility to independent inventors and very small companies. A few of the many comments from this clientele quoted from the Oak Ridge National Laboratory questionnaire are listed below:

> Without the funding from ... ERIP ... we could not have made the improvements and obtained the subsequent patent to stay in business!
>
> [ERIP] Supplied the initial funds to get started. Also provided credibility to raise funds on our own once we did get started.
>
> ERIP provided the "shot in the arm" to get the technology going. The technology would never have existed without ERIP help.
>
> Our product's association with the program gave our product and concept instant credibility with potential customers and investors.

These program testimonials provide further evidence that these benefits would not have occurred without support from ERIP (names and further information are available upon request).

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[1] January 1995 telecom with Kelly McGeough of Venture Economics, Cambridge, Massachusetts, from "Venture Economics Annual Statistics–1993."

Q368. Page 506 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following Inventions and Innovations Program performance metrics for FY 1995 and FY 1996:

Measure:

	1995	1996
Annual Quads Saved	**.059**	**.060**
Annual Sales Millions of $	**59**	**60**
Success Rate	**24%**	**25%**
Funds Leverage Ratio	**2:1**	**3:1**
Co-funding Partners	**--**	**4**

Please provide detailed documentation for each of these claimed performance metrics in FY 1995 and FY 1996, including identification of each "Co-funding Partners", in FY 1996 and the amount of co-funding.

A368. Current and projected energy savings are based on data collected over a 12-year period from funded technologies by a biennial program evaluation conducted by Oak Ridge National Laboratory (ORNL). The ORNL evaluation involves mailing an OMB-approved questionnaire to all participants in the Energy-Related Inventions Program. The listing below summarizes the chief areas of interest on the questionnaire:

- Provide the title and a brief description of your technology.
- Provide the name of the contact and how the contact is associated with this project.
- Describe the contact's employment history with this company and others.
- Describe the contact's education background, age, and inventor's position at the time of conceptualization.
- Describe patenting activity and distribution strategy for the technology.
- Describe the activity and development status of this technology.
- Provide information on field tests and demonstrations of the technology.
- Provide sales data and licensing revenues.
- Discuss employment levels and spinoff technologies.
- Provide information on other sources of funding for the technology.
- Describe the contact's experience with startup companies.

Q368. Page 506 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following Inventions and Innovations Program performance metrics for FY 1995 and FY 1996:

Measure:

	1995	1996
Annual Quads Saved	**.059**	**.060**
Annual Sales Millions of $	**59**	**60**
Success Rate	**24%**	**25%**
Funds Leverage Ratio	**2:1**	**3:1**
Co-funding Partners	**--**	**4**

Please provide detailed documentation for each of these claimed performance metrics in FY 1995 and FY 1996, including identification of each "Co-funding Partners", in FY 1996 and the amount of co-funding.

A368. Current and projected energy savings are based on data collected over a 12-year period from funded technologies by a biennial program evaluation conducted by Oak Ridge National Laboratory (ORNL). The ORNL evaluation involves mailing an OMB-approved questionnaire to all participants in the Energy-Related Inventions Program. The listing below summarizes the chief areas of interest on the questionnaire:

- Provide the title and a brief description of your technology.
- Provide the name of the contact and how the contact is associated with this project.
- Describe the contact's employment history with this company and others.
- Describe the contact's education background, age, and inventor's position at the time of conceptualization.
- Describe patenting activity and distribution strategy for the technology.
- Describe the activity and development status of this technology.
- Provide information on field tests and demonstrations of the technology.
- Provide sales data and licensing revenues.
- Discuss employment levels and spinoff technologies.
- Provide information on other sources of funding for the technology.
- Describe the contact's experience with startup companies.

- Describe the energy and environmental relationship of the technology.

- Rate the value of the ERIP assistance.

The ORNL staff analyzes, aggregates, and summarizes these data in a biennial report to ERIP. The individual data are aggregated to avoid releasing to the public any proprietary financial or business information. Therefore, the data in the performance metrics above are from actual data submitted by inventors, not created by guessing or overestimating the contribution that each of the technologies may have made to the country. Energy savings in quads, sales, success rates, and funds leveraged are based specifically on data collected from inventions supported by ERIP that have entered the marketplace.

For example, a simple count of the number of companies known to be in the market-place divided by the number in the study reveals 24 percent for FY 1995. The ratio of 3:1 for leveraging in FY 1996 is based on actual financial contributions from the inventors themselves; this ratio does not include any in-kind contribution from the inventor, such as reduced overhead, absorbed costs above a certain ceiling, and so forth.

It is not ERIP policy to require co-funding because we know that the inventor community is plagued by a paucity of capitalization to begin with. Therefore, it is indeed fortuitous when the inventor is able to locate a partner who is willing to provide co-funding. To date, there are three examples of co-funding on two projects this fiscal year:

Dr. Alvon C. Elrod (contact), Clemson University, Clemson, SC
Michael T. Nelson (inventor), Clemson, South Carolina
Chrysler Corp. is providing $362,200 toward the development of the so-called "Clemson Camshaft," an innovation that uses a single camshaft to manage the timing events and their duration in an internal combustion engine; Unisia Jecs is providing $39,250 for the same project.

R. Bardin Redditt (inventor), Greenwood, Mississippi
The National Catfish Producers Association is providing $25,000 toward the development of Mr. Redditt's patented automatic oxygenation system for aquaculture for catfish farming.

Q369. Please provide a listing of the recipients of (i) the $5,714,000 in funding in FY 1995, (ii) the $5,387,000 in FY 1996 funding, and (iii) the requested level of $5,200,000 in FY 1997 for Inventions & Innovation.

A369. The information requested is shown below:

Recipients
National Institute of Standards and Technology
ERIP Grants to Inventors
InnCon Grants to Inventors
Virginia Tech
Dawnbreaker
Naval Petroleum Reserve
SEMA
Future-Tec
New Horizons
Oak Ridge National Lab
Pacific Northwest National Lab
SBIR and other technology support
National Renewable Energy Lab

Q370. For each recipient of Inventions & Innovation funds identified in the response to question 369 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A370. The requested information is provided in the following table:

Recipient	Cost-Share FY 1995	Cost-Share FY 1996	Cost-Share FY 1997
National Institute of Standards and Technology	N/A	N/A	N/A
ERIP Grants to Inventors	$326,269	$1,045,719	TBD
InnCon Grants to Inventors	$0	$0	TBD
Virginia Tech	N/A	N/A	N/A
Dawnbreaker	N/A	N/A	N/A
Naval Petroleum Reserve	N/A	N/A	N/A
SEMA	N/A	N/A	N/A
Future-Tec	N/A	N/A	N/A
New Horizons	N/A	N/A	N/A
Oak Ridge National Laboratory	N/A	N/A	N/A
Pacific Northwest National Laboratory	N/A	N/A	N/A
SBIR and other technology support	N/A	N/A	N/A
National Renewable Energy Laboratory	N/A	N/A	N/A
Carryover	N/A	N/A	N/A

Q371. For those Inventions & Innovation funding recipients identified in the response to question 369 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A371. The table below summarizes the information requested:

RECIPIENT	INSTRUMENT	JUSTIFICATION
National Institute of Standards and Technology	Interagency Agreement	P.L. 93-577 mandates the National Bureau of Standards (now the National Institute of Standards and Technology) to conduct technical evaluations of energy-related inventions.
ERIP Grants to Inventors	Grant	P.L. 93-577 recommends providing financial assistance to support promising energy-related inventions. DOE uses its unsolicited proposal procedure to fund the technology development funding requests.
Virginia Tech	Cooperative Agreement	Authorized in accordance with 10 CFR, Section 600.7 of the Federal Assistance Regulations for the continuation of an educational activity.
Pacific Northwest National Laboratory	Program Letter	Authorized in accordance with government- wide policies on Federally Funded Research & Development Centers (FFRDC) issued by the Office of Federal Procurement Policy in April 1984.
Oak Ridge National Laboratory	Program Letter	Authorized in accordance with government- wide policies on Federally Funded Research & Development Centers (FFRDC) issued by the Office of Federal Procurement Policy in April 1984.
Naval Petroleum Reserve in CO, UT & WY	Program Letter	Authorized in accordance with government- wide policies on Federally Funded Research & Development Centers (FFRDC) issued by the Office of Federal Procurement Policy in April 1984.
National Renewable Energy Laboratory	Program Letter	Authorized in accordance with government- wide policies on Federally Funded Research & Development Centers (FFRDC) issued by the Office of Federal Procurement Policy in April 1984.

Management and Planning

Q372. Please provide a listing of the recipients of (i) the $842,000 in funding in FY 1995, (ii) the $600,000 in FY 1996 funding, and (iii) the requested level of $600,000 in FY 1997 for Evaluation and Planning.

A372. The following organizations received funding:

FY 1995:	Pacific Northwest Laboratory; Coopers and Lybrand; Vista Technology, Incorporated; Energetics, Incorporated; Research Management Consultants, Incorporated.
FY 1996:	Energetics, Incorporated; Vista Technology, Incorporated.
FY 1997:	Planned: Mele Associates; Energetics, Incorporated; TBD.

Policy and Management–EC

Q373. Please provide a listing of the recipients of (i) the $5,413,000 in funding in FY 1995, (ii) the $3,956,000 in FY 1996 funding, and (iii) the requested level of $3,139,000 in FY 1997 for Policy and Management Headquarters Contractual Services.

A373. The funds support essentially three broad categories of work: (1) the Working Capital Fund, (2) high-priority work with the National Laboratories; and (3) support service activities. Most of the funds ($2,587,000 in FY 1995; $2,620,000 in FY 1996; and $3,000,000 in FY 1997) support the Department's Working Capital Fund. Starting in FY 1997 this account will support activities such as rent, automated office support, contract close out, contract audits, SES awards, telephone services, postage, graphics, and similar services previously included in the Departmental Administration account. Actual vendors and service providers will be obtained on a competitive basis or through the most cost-saving vehicle available.

Funds for the National Laboratories ($2,206,000 in FY 1995; $726,000 in FY 1997) and $139,000 in FY 1997) support the following: (1) development of quality metrics and performance measurement data in compliance with the Government Performance and Results Act (GPRA) of 1993; (2) the Government Management Reform Act (GMRA) of 1994; (3) the Federal Acquisition Streamlining Act of 1994; and (4) the Information Technology Management Reform Act (ITMRA) of 1996. The Laboratories used by the Office of Energy Efficiency and Renewable Energy are world renown for their expertise in these areas and, therefore, the work is not competed.

Finally, professional and administrative support services ($621,000 in FY 1995, $610,000 in FY 1996; and $0 in FY 1997) are obtained on a competitive basis from several vendors.

Q374. For those Policy and Management Headquarters Contractual Services listed in 373 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A374. Funding for the National Laboratories is not competed because the National Laboratories have unique knowledge and operating experience with Energy Efficiency and Renewable Energy programs which is directly applicable to the development of the needed information on quality metrics and performance measurement data. Some of the funding for the Working Capital Fund is not competed since there is no viable service provider for activities such as postage and rent from GSA.

Q375. Please provide a listing of the recipients of (i) the $845,000 in funding in FY 1995, (ii) the $1,170,000 in FY 1996 funding, and (iii) the requested level of $1,705,000 in FY 1997 for Golden Field Office Contractual Services.

A375. Most of the funding is for GSA rent charges and the balance is for management and administrative support services with L.S. Gallegos and Associates, which is a competitively awarded contract.

Q376. For those Golden Field Office Contractual Services listed in 375 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A376. The only non-competitive funded activities are those where there is no viable service provider for activities such as postage and rent from GSA.

Q377. Please provide a listing of the recipients of (i) the $4,970,000 in funding in FY 1995, (ii) the $3,227,000 in FY 1996 funding, and (iii) the requested level of $2,080,000 in FY 1997 for Regional Support Offices Contractual Services.

A377. The contractual services for the Regional Support Offices (RSOS) provides for those costs associated with the operation of the ten RSOs in FY 1995 and six in FY 1997. This includes activities such as rent, automated office support, printing and graphics, telephone and communications services, postage, GSA vehicles, and automatic data processing (ADP) activities. The costs for rental of office space in the cities where the RSOs are located is the largest cost element and totals $1,700,000 in FY 1995, $1,270,000 in FY 1996, and $980,000 in FY 1997. The costs for ADP data entry, ADP systems support, and ADP hardware and software are obtained on a competitive basis from vendors in each city in which the RSOs are located.

The only non-competitive funded activities are those where there is no viable service provider for activities such as postage and rent from GSA.

Q378. For those Regional Support Offices Contractual Services listed in 377 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A378. The only non-competitive funded activities are those where there is no viable service provider for activities such as postage and rent from GSA.

Q379. Page 525 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request* contains the following claims for cumulative benefits of the International Market Development Program:

	1997	2000	2010	2020
Exports ($million)	58	62	80	102
Federal Tax revenues	15	16	20	26

Q379a. Please provide detailed documentation of each of these claimed benefits.

A379a. The above projected benefits result from an intensive internal effort to develop peer-reviewed metrics of the impacts of renewable energy and energy efficiency programs at DOE. This effort began three years ago and relies on market studies and expert opinion, together with modeling of those market segments for which such techniques are appropriate. The process through which this methodology was developed included stakeholder input and a peer review by industry experts. The direct measurement of the benefits of commercialization efforts is difficult due to the time lag between the initial Federal effort and actual sales or exports. However, estimates of sales were derived from work being done at the Department of Commerce and the California Energy Commission. The resulting benefits values presented in the above table represent our best estimate of what is possible to achieve based on the economic and technology progress assumptions that were made. These results are currently being reviewed by Arthur D. Little, Incorporated.

Q379b. Please provide evidence that these benefits would not occur in the absence of DOE funding.

A379b. The benefits cited are based on past and expected future technology sales resulting from DOE support, of energy efficiency technologies. We cannot state with certainty that all the private efforts toward export of these technologies would cease without the Federal program, but we do know that in many cases the Federal funding provided invaluable assistance to U.S. firms seeking to enter overseas markets.

Q380. Please provide a listing of the recipients of (i) the $2,869,000 in funding in FY 1995, (ii) the $2,845,000 in FY 1996 funding, and (iii) the requested level of $2,900,000 in FY 1997 for the International Market Program Development Program.

A380. The requested information is provided in the following table:

Recipient	FY95	FY96	FY97
Export Council for Energy Efficiency	$861,000	$925,000	
NOVEM	299,345	300,000	
Oak Ridge National Laboratory	550,000	700,000	
Energy Technology Support Unit	105,655	105,000	
National Renewable Energy Laboratory	550,000	340,000	
Pacific Northwest National Laboratory	286,000		
International Fund for Renewable Energy and Energy Efficiency		25,000	
Electric Power Research Institute		70,000	
Argonne National Laboratory		85,000	
CAMBER, Corporation	122,000	75,000	
TBD			$2,900,000

Q381. For each recipient of International Market Program Development funds identified in the response to question 380 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A381. The contracts awarded by the International Market Development program did not incorporate provisions for cost-sharing.

Q382. For those International Market Program Development funding recipients identified in the response to question 380 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A382. Laboratory funding is based on a determination by DOE project managers that laboratory staff are uniquely qualified to accomplish work assignments. The Department's relationship with the laboratories is set by the M&O contracts awarded through competitive procurements for the management of each laboratory. Funding to other organizations on a non-competitive basis, including the Export Council for Energy Efficiency, IFREE, EPRI, NOVEM, ORNL, and ETSU is also based on a determination by DOE project managers that their staff are uniquely qualified and have exclusive capabilities to accomplish work assignments.

Q383. Please provide a listing of the recipients of (i) the $1,894,000 in funding in FY 1995, (ii) the $1,605,000 in FY 1996 funding, and (iii) the requested level of $3,000,000 in FY 1997 for the Information and Communications Program.

A383. The requested information is provided in the following table:

Recipient	FY95	FY96	FY97
National Renewable Energy Laboratory	$2,153,000	$1,345,000	$1,360,000

Q384. For each recipient of Information and Communications Program funds identified in the response to question 383 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995 - FY 1997.

A384. There was no cost sharing.

Q385. For those Information and Communications funding recipients identified in the response to question 383 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A385. See question 383. All funding was awarded to the National Renewable Energy Laboratory.

The Honorable Patricia Fry Godley
Assistant Secretary for Fossil Energy
U.S. Department of Energy

Answers to Prehearing Questions

Prehearing Questions for April 17, 1996, Hearing of the Subcommittee and Energy and Environment, Committee on Science, U.S. House of Representatives, on the Department of Energy's Fiscal Year 1997 Budget Request for the Office of Fossil Energy Submitted to The Honorable Patricia Fry Godley, Assistant Secretary for Fossil Energy

Office of Fossil Energy Program Mission

Q1. On page 15 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "A key driver for FE gas and oil activities is the recently completed National Petroleum Council study 'Research, Development, and Demonstration Needs of the Oil and Gas Industry.' The study identifies high benefit R&D areas, considering the near- and long-term needs of both the upstream and downstream sectors, where industry, for a variety of reasons, does not believe it will make adequate progress on its own."

Please provide a copy of this report.

1. A copy is provided. *[Note that this study comprises three volumes. Volume I (Summary and discussion is reproduced here. Volumes II and III are contained in Subcommittee files.]*

RESEARCH DEVELOPMENT AND DEMONSTRATION NEEDS OF THE OIL AND GAS INDUSTRY

VOLUME I

Summary and Discussion

A REPORT OF THE NATIONAL PETROLEUM COUNCIL • AUGUST 1995

RESEARCH DEVELOPMENT AND DEMONSTRATION NEEDS OF THE OIL AND GAS INDUSTRY

VOLUME I

Summary and Discussion

A REPORT OF THE NATIONAL PETROLEUM COUNCIL • AUGUST 1995
W. W. Allen, Chair, Committee on Research and Development Needs

NATIONAL PETROLEUM COUNCIL

H. Laurance Fuller, *Chair*
Dennis R. Hendrix, *Vice Chair*
Marshall W. Nichols, *Executive Director*

U.S. DEPARTMENT OF ENERGY

Hazel R. O'Leary, *Secretary*

The National Petroleum Council is a federal advisory committee to the Secretary of Energy.

The sole purpose of the National Petroleum Council is to advise, inform, and make recommendations to the Secretary of Energy on any matter requested by the Secretary relating to oil and natural gas or to the oil and gas industries.

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PREFACE

On July 27, 1994, Energy Secretary Hazel R. O'Leary asked the National Petroleum Council (NPC) to conduct a new study of research, development, and demonstration (RD&D) needs of the U.S. oil and gas industry. Specifically, she requested:

> that the National Petroleum Council conduct a study of research, development, and demonstration needs of the natural gas and oil industry. This study should analyze the needs of all components of the industry, considering the near- and long-term needs of both the upstream and downstream sectors.

(See Appendix A for the complete text of the Secretary's request letter and a description of the National Petroleum Council.)

The NPC established the Committee on Research and Development Needs to prepare a proposed response to the Secretary's request. The Committee was chaired by W. W. Allen, Chairman of the Board and Chief Executive Officer, Phillips Petroleum Company. Patricia Fry Godley, Assistant Secretary, Fossil Energy, served as the Committee's Government Cochair. The Committee was assisted by a Coordinating Subcommittee and two Task Groups. (See Appendix B for rosters of the Committee, Coordinating Subcommittee, and Task Groups.)

The study analyzes the needs of the industry, considering the near- and long-term needs of both the upstream and downstream sectors. The scope encompasses natural resource identification through the output of the refinery and the gas processing facilities. In addition, the study examines the relevant capabilities and role the nine national laboratories and the National Institute for Petroleum and Energy Research (NIPER)[1] could play in providing technical and scientific support to the industry.[2] The role of other public and private labs also is discussed.

In addition to presenting information on the technology needs of the industry, the study presents information on the importance of oil and gas to the vitality of the

---

[1] Argonne, Brookhaven, Idaho National Engineering Laboratory, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, Sandia, and NIPER are collectively referred to as The Labs in this report.

[2] The scope distinguishes this study from the Galvin task force on *Alternative Futures for the Department of Energy National Laboratories*, the Yergin Task Force on *Strategic Energy R&D*, and the NPC Committee on the *Issues and Policies Affecting the Future of the Oil and Gas Industries*.

American economy and insights into new approaches for conducting oil and gas RD&D in the coming years. The study describes the mechanisms that could be used to effectively match unique technical capabilities with the technology needs identified by industry. Importantly, the perceived barriers to collaboration that must be addressed to foster a better climate and receptivity to joint activities are also addressed in this report.

This study is presented in three volumes. Volume I contains the body of the report, including the Council's recommendations and the analyses supporting them. Volume II presents the NPC's 1995 Survey of Research and Development Needs, which provides the data describing the research and development needs of the oil and gas industry. Volume III contains detailed data on the capabilities of the nine DOE national laboratories and NIPER.

EXECUTIVE SUMMARY AND RECOMMENDATIONS

THE U.S. OIL AND GAS INDUSTRY—CURRENT AND FUTURE

For nearly one hundred years the oil and gas industry has been essential to the economic growth, high standard of living, and national security of the United States. There remain large known reserves and undiscovered resources of oil and gas in the U.S. and worldwide. Even with progress in the development and use of alternative energy sources, the reality is that oil and gas will continue to be essential. Statistical data on the oil and gas industry may be found in Appendix C.

Oil and gas supplied nearly 65 percent of the total U.S. energy demand in 1993. In addition, although the overall Consumer Price Index has increased by 75 percent between 1980 and 1993, the indexes for fuel oil and motor fuel are at 1980 levels. These and other data in this report illustrate the importance of oil and gas to a strong U.S. economy.

In our vision of the future, the competitive edge of the industry will increasingly depend on the ability to manage and apply technology effectively and rapidly. This will include leadership in technology for environmentally sound operations and environmentally acceptable hydrocarbon fuels.

The industry faces significant challenges to effectively and efficiently finding, producing, and processing new reserves of oil and gas, and converting these reserves into products while complying with regulations at acceptable costs. Advancing technologies are expected to play an important role in meeting these challenges. *The NPC believes that achievement of the necessary technological advancements is a strategic imperative for both the industry and the nation.*

In a companion report to the Secretary of Energy, entitled *Future Issues—A View of U.S. Oil & Natural Gas to 2020*, the Council explores more deeply the value of the oil and gas industry to the economy and the full spectrum of issues the industry will face over the next 25 years.

KEY TECHNOLOGY NEEDS

The assessment of the current RD&D needs of the industry is a primary focus of this study. The oil and gas industry's technology needs were determined by the combination of a comprehensive survey sent to a large cross-section of the industry (primary data) and an analysis of other pertinent studies completed in the last several years (secondary data).

The survey was developed to determine the desired technology advances, their impact, and their likelihood of commercial availability both in the short term (by 1999) and the long term (between 1999 and 2010). The survey was sent to 130 members of the National Petroleum Council. The responses included information on 250 technologies in 11 technology areas:

- Exploration
- Development
- Drilling and Completion
- Production
- Deepwater Offshore
- Arctic Region Activities
- Oil Processing and Refining
- Gas Processing
- Gas Gathering
- Gas Storage
- Environment and Regulatory.

The 89 companies who responded to the survey reported U.S. reserves of 11.8 billion barrels of oil and 74.6 trillion cubic feet of gas—*or about 50 percent of total U.S. reserves*. The companies also reported worldwide oil reserves of 24 billion barrels and worldwide gas reserves of 128 trillion cubic feet. The respondents' U.S. refining capacity is 9 million barrels per day, which is about 60 percent of U.S. capacity. The blank survey form and the results of the survey are in Appendix D (Volume II of this report).

The survey was designed to identify specific advances needed in each technology area, the expected level of impact and timing of technology advances, and the degree of willingness to collaborate to advance these technologies. A further purpose was to identify issues that are barriers to technical collaborations with other oil and natural gas companies, DOE, the national laboratories, universities, and other public and private laboratories.

An analysis of the survey responses identified 36 technologies that are highest priority based on their impact on business and their likelihood of not being met under a business-as-usual scenario. These technologies are shown in Figure 1. Although the figure is a composite, the detailed survey results shown in the appendices indicate that majors, other integrated oil and gas companies, independents, and service companies have distinct technology needs. The following examples illustrate some of the highest priority distinct technology needs from the survey.

In the upstream,

- High priority needs for majors and independents were:
  - High-resolution depth imaging
  - Improved well productivity
  - Hydrate control and prevention.
- High priority need for service companies was horizontal well technology.
- Paraffin control was rated to have high impact for independents, but not for majors.

In the downstream for majors and independents, high priority needs were:

- Catalysts with improved selectivities, yields, and lifetimes
- New approaches to refining heavy feeds
- Improved energy efficiency of processes and equipment
- Improved plant and process reliability.

In the environmental area, a high priority industry need was a scientific basis for risk-based environmental regulation.

CAPABILITIES OF THE LABS

The development of technology for the oil and gas industry is accomplished through a variety of sources well known to the industry including in-house oil and gas company RD&D programs, universities, research institutes, and service companies. Recently the government laboratories have become increasingly involved in RD&D; however, the capabilities of these labs are less well known to the industry. In order to completely respond to the request of the

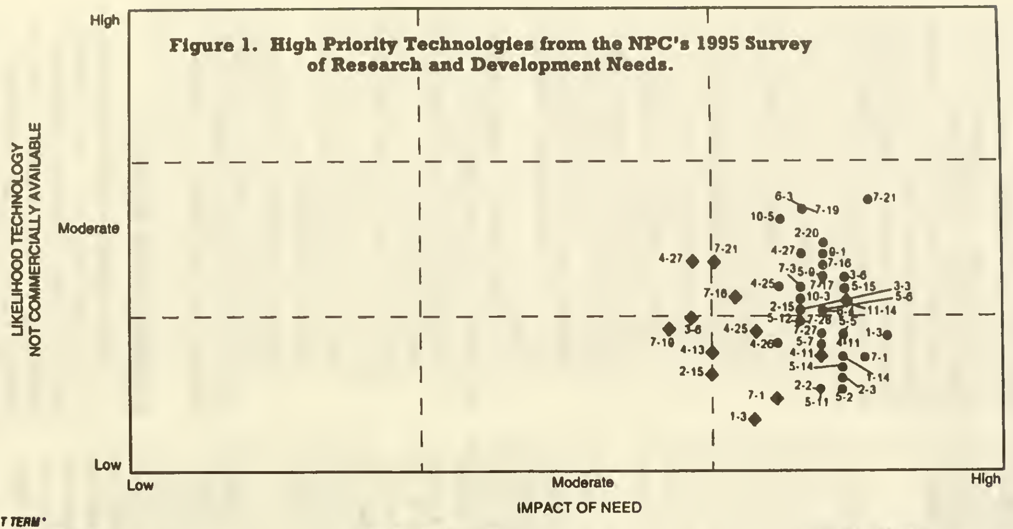

Figure 1. High Priority Technologies from the NPC's 1995 Survey of Research and Development Needs.

● *SHORT TERM* *

Q.1		**Exploration**
1-3	(51)	High-resolution seismic depth imaging
1-14	(46)	Advanced seismic acquisition
Q.2		**Development**
2-2	(45)	Computer-based 3D geological modeling
2-3	(43)	Development-scale seismic applications
2-15	(50)	Through casing logging
2-20	(46)	Permeability logging techniques
Q.3		**Drilling And Completion**
3-3	(49)	Advanced fracture techniques
3-6	(47)	Well productivity
Q.4		**Production**
4-11	(53)	Stimulation techniques
4-25	(49)	Near well bore stimulation
4-26	(43)	New directional drilling
4-27	(39)	Advanced recovery of natural gas
Q.5		**Deep Water Offshore**
5-2	(20)	Extended reach drilling or production
5-5	(12)	Flowlines
5-6	(13)	Flow metering
5-7	(15)	Subsea equipment
5-9	(14)	Risers
		Deep Water Offshore (continued)
5-11	(20)	Drilling
5-12	(11)	Workover
5-14	(11)	Hydrate prevention
5-15	(11)	Multi-phase pumps
Q.6		**Arctic Region Activities**
6-3	(7)	Development
6-4	(10)	Drilling
Q.7		**Oil Processing and Refining**
7-1	(22)	Catalysts with improved selectivities yields, lifetimes
7-3	(19)	Plant and process reliability
7-16	(21)	Energy efficiency of processes
7-17	(19)	Energy efficiency of equipment
7-19	(14)	Separations technologies
7-21	(10)	New approaches to refining heavy feeds
7-27	(10)	Performance characteristics of new hydrocarbon fuel compositions
7-28	(14)	Environmental characteristics of new hydrocarbon fuel compositions
Q.9		**Gas Gathering**
9-1	(30)	Compression
Q.10		**Gas Storage**
10-3	(11)	Reservoir management
10-5	(9)	Base gas minimization techniques
Q-11		**Environmental and Regulatory**
11-14	(41)	Provide scientific basis for risk-based regulation

◆ *LONG TERM* *

Q.1		**Exploration**
1-3	(27)	High-resolution seismic depth imaging
Q.2		**Development**
2-15	(22)	Through casing logging
Q-3		**Drilling and Completion**
3-6	(26)	Well productivity
Q-4		**Production**
4-11	(21)	Stimulation techniques
4-13	(18)	Recompletion techniques
4-25	(19)	Near well bore stimulation
4-27	(28)	Advanced recovery of natural gas
Q-7		**Oil Processing and Refining**
7-1	(14)	Catalysts with improved selectivities yields, lifetimes
7-16	(15)	Energy efficiency of processes
7-19	(21)	Separations technologies
7-21	(21)	New approaches to refining heavy feed

* Numbers in parentheses indicate number of responses.

Secretary, specific information was compiled on the RD&D projects and capabilities in The Labs[1] directed at the needs of the oil and gas industry.

The comprehensive data compiled on The Labs are contained in Appendix E (Volume III of this report), which includes:

- *Project Summaries*: These provide quantitative information in the form of one-page summaries of projects that reflect current capabilities being applied in areas of direct interest to the petroleum industry. In preparing these summaries, The Labs used the 11 technical categories listed in the survey. The major purpose of the project summaries is to relate the capabilities of The Labs to the technology needs as identified by industry.
- *Enabling Capabilities*: Descriptions of enabling capabilities or technical strengths of The Labs that have potential value to, but that are not necessarily now being applied to, the petroleum industry, and thus may not be captured in the project summaries.
- *Historical Legacy*: Each of The Labs was given the opportunity to describe its "legacy" that led to its current technology position vis-a-vis the oil and gas industry.

The cumulative industry-related RD&D project expenditures for The Labs during the period FY91-FY95 were almost $600 million. The Labs have significant efforts in the technology needs categories of Environmental and Regulatory, Oil Processing and Refining, and Development technologies. Together, these represent 75 percent of the funding and 73 percent of the projects identified by The Labs. Total funding during the last five years for these three technical categories is nearly $450 million. The Labs participate at a modest level in the technology needs categories of Exploration, Drilling and Completion, and Production. Total funding during the last five years for these three technical categories is about $106 million and represents nearly 18 percent of the funding and 18 percent of the projects identified by The Labs.

The $600 million cumulative industry-related RD&D project expenditures for The Labs are equivalent to 5 percent of the annual expenditures of the respondents. The Labs have doubled their active projects with industry, with expenditures increasing from $70 million per year in 1991 to $190 million per year in 1995.

The data show that The Labs have impressive research and development capabilities in many energy related technologies. However, in order for the RD&D to be effective, these capabilities should be aligned with the long-term missions of The Labs and the users' needs. It is therefore very important to increase user input into the selection and conduct of The Lab RD&D programs. The NPC industry needs survey indicated considerable interest within the industry to collaborate on RD&D projects to develop oil and gas technology. This forms a basis for cooperation with The Labs in selected areas of RD&D.

Research efforts at universities and other public and private research organizations are a central component of the RD&D activities of the industry. The impact of DOE expenditures and/or increased oil and gas research at The Labs must be carefully considered in establishing DOE funding priorities.

The industry currently benefits from some RD&D projects that utilize the unique facilities that are available at The Labs, such as high-intensity photon sources. These joint projects with the oil and gas industry enable leading edge research to be conducted in a variety of areas that would be difficult otherwise. The Labs should continue to cooperate with industry by making these special facilities available for collaborative RD&D on a priority basis consistent with the primary mission of The Labs.

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[1] Argonne, Brookhaven, Idaho National Engineering Laboratory, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, Sandia, and NIPER are collectively referred to as The Labs in this report.

The Labs have strong capabilities in fundamental science and engineering, which could be very effective in the conduct of basic research needed by the oil and gas industry. The relevance and impact of this research can be maximized by review and guidance by direct industry participants. The results of this RD&D should be made available to all components of the U.S. oil and gas industry.

The Labs should emphasize technology development efforts in the areas of environmental technology that impact the oil and gas industry. The Labs, in close cooperation with industry, should work to develop a scientific basis for emission, effluent, and cleanup standards that balance the need to minimize risk to human health and ecosystems with the costs and benefits of control and cleanup technologies.

The Labs can play an effective role in applied RD&D provided there is strong direction from industry in the definition of goals and funding levels for these projects. Direct industry involvement is a critical success factor for applied RD&D.

DEVELOPERS AND SUPPLIERS OF ADVANCED TECHNOLOGY

A "new paradigm" for oil and gas RD&D is evolving because intense competition that contributes to low oil and gas prices, and the need to reallocate scarce funds for large investments related to environmental compliance, have forced the industry to re-evaluate every aspect of its business, including their RD&D investments. This re-evaluation brought better efficiency and cost-effectiveness to private sector RD&D activities. In many companies, in-house programs have moved toward projects that are likely to provide a competitive advantage and a nearer term payout. Industry also compensated for smaller in-house programs by making greater use of collaborations for technology development with many different entities. The new RD&D paradigm evolved from the business, regulatory, and technological needs of the industry. One of the outcomes is a user-driven, strategic, and collaborative RD&D effort that culminates in application. The new paradigm in oil and gas RD&D meets the demands of the marketplace and encompasses leveraging, cost-effectiveness, and an increased focus on user-driven RD&D.

The willingness to collaborate and form technology alliances with all types of other organizations, including other oil and gas companies, research consortiums, universities, DOE, the national laboratories, and other consortia has increased with the emergence of the new paradigm (see Table 1). However, in order to be successful, these collaborations must be focused on user-driven technology development.

The survey showed a relatively high overall willingness to collaborate. Sixty-three percent of all responses to the survey question for each technology indicated a willingness to collaborate. The willingness varied both by technology area and industry sector. There was a

Paradigms for Meeting RD&D Needs

	OLD PARADIGM		NEW PARADIGM
Source of Technology:	In-House	———>	Leverage & Collaborate
Project Prioritization:	Technology Push	———>	User Needs
Motive:	Own It	———>	Use It

TABLE 1

WILLINGNESS TO COLLABORATE ON A SPECIFIC TECHNOLOGY
(Percent of Responses)

	Vendors/ Service Com-panies	Oil & Gas Com-panies	Univer-sities	Research Institutes	Trade Assoc.	National* Labs.	DOE†	USGS/ State Survey
All Respondents	*53*	*51*	*48*	*46*	*43*	*42*	*41*	*36*
Majors	66	57	59	56	49	49	44	41
Other Integrated	55	53	43	43	45	35	35	35
Independents	49	48	44	43	43	41	42	35
Service	33	46	39	29	21	34	34	27

*The National Laboratories are Argonne, Brookhaven, Idaho National Engineering Laboratory, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, and Sandia.

†Collaboration with DOE refers to cost-sharing arrangements with Morgantown Energy Technology Center, Pittsburgh Energy Technology Center, National Institute for Petroleum and Energy Research, Metairie Site Office, and Rocky Mountain Oilfield Testing Center.

higher interest in collaboration for meeting shorter term needs than longer term needs. When asked the question in general, with no specific technology, there was a greater willingness to collaborate than is presently occurring. This indicates that increased collaboration is likely to occur if perceived barriers are addressed.

The barriers to collaboration with DOE and national laboratories identified by the respondents included excessive paperwork, hold harmless agreements, uncertainty of ongoing funding, red tape, confidentiality issues, intellectual property issues, limited resources, and alignment issues such as differing business objectives, goal orientation, and timelines. These issues/perceptions need to be addressed if DOE and The Labs desire a customer orientation that will result in an increase in collaboration.

CONCLUSIONS AND RECOMMENDATIONS

This study on RD&D needs could be the starting point for establishing an improved process of focused oil and gas RD&D unprecedented by previous efforts. The current need to improve efficiencies and control costs makes such an effort timely and imperative. The theme of these recommendations is for the Secretary to establish a process that embodies the "new paradigm" in oil and gas RD&D *user-driven technology development.* Regardless of the final spending levels, this approach will improve efficiencies and cost-effectiveness.

Many Council members believe there is a place for industry-government collaboration in the development of oil and gas technology. However, there is a wide range of opinions among NPC members concerning both the value and the desirability of a government role. At one end of the spectrum is the belief that government should leave the significant components and expenditures for energy RD&D to the private sector, and that RD&D tax incentives for industry are preferred over government funding of opportunities for collaboration. Those at the opposite end of the spectrum hold that energy RD&D is so important to our national and economic security that it should not be entirely the responsibility of the private sector.

Council members who see value in collaboration with government stress that their position does not represent a blank check. The level of government RD&D funding was not addressed in this study. Any oil- and gas-related research undertaken by government should be focused on areas of user-identified technology needs, and must be timely and cost-effective.

The NPC recognizes that public debate is continuing and policy decisions are continuously being reviewed regarding government's role. In addition, there is congressional and administrative review of DOE's budget, as well as other government expenditures. Realignment efforts presently underway at DOE offer an opportunity to develop new and improved processes to prioritize government spending in the area of energy RD&D expenditures and programs.

The interest within the industry, indicated by our survey, to expand collaborative RD&D to develop oil and gas technology presents a positive opportunity for both the Department of Energy and the industry. The Council and its members are interested in working with DOE on programs that focus on user needs and to develop new programs and policies that meet the changing dynamics of the RD&D needs of the oil and gas industry. The following recommendations are presented in the same spirit of cooperation and improvement that led the Secretary of Energy to request this report on the RD&D needs of the oil and gas industry.

The Secretary of Energy should immediately utilize and fully incorporate this study's analysis into the Department of Energy's current realignment activities, program development, spending prioritization, and budgeting activities at all levels of DOE's strategic planning activities.

The Department of Energy should focus its sponsorship of research on areas of technology needs that cannot be effectively conducted in the private sector.

Current and newly proposed expenditures should be analyzed in order to match the high impact needs identified by the analysis in this report with the unique capabilities of The Labs. The focus in this activity should be on the highest priority needs which benefit all industry participants without competing with the private sector developers of technology.

Continuity should be provided for logical (cost-effective) completions of all short-term projects, no matter how the industry-Lab RD&D collaborations change over the next few years. Long-term projects should be judged individually and be provided transitional funding as necessary.

The Department of Energy should place greater emphasis on prioritizing RD&D programs based on the industry's needs and participation. Current efforts by DOE and the government laboratories, such as the *Natural Gas and Oil Technology Partnership* and the *Refinery of the Future* initiative, have improved processes and identified initiatives through which the oil and gas industry can leverage its resources. Improved processes or mechanisms are needed to accommodate industry input.

The Department of Energy should develop a project definition system that utilizes broadly based industry input to prioritize and recommend all DOE funding that is directly related to oil and gas research, development, and demonstration needs. This process should ensure a user-driven, strategic, and collaborative RD&D effort that eliminates duplication.

DOE and the government laboratories should remove barriers to collaboration. To implement this recommendation, DOE should initiate simplified administrative procedures that minimize paperwork and the turnaround time for bringing technology to practical application.

The government laboratories should not become a technical services organization competing with industry resources. The NPC concurs with the Galvin task force recommendation that the activities at the national laboratories should be privatized as appropriate.

The NPC believes that the implementation of the above recommendations will result in more effective and efficient oil and gas research, development, and demonstration.

CHAPTER ONE

THE U.S. OIL AND GAS INDUSTRY— CURRENT ROLE AND VISION OF FUTURE

The oil and gas industry is vital to a strong U.S. economy. To introduce this report on the research, development, and demonstration needs of the oil and gas industry, NPC members believe it is important to discuss the current role of the industry, the industry's vision of the future, and the challenges to attaining that vision. Because the oil and gas industry is vital to a strong U.S. economy, any challenges to maintaining a strong domestic oil and gas industry can and must be overcome.

For nearly one hundred years, the U.S. oil and gas industry has been essential to the economic growth, high standard of living, and national security of the United States. Large known and undiscovered reserves of oil and gas remain in the U.S. and worldwide. Even with progress in the development and use of alternative energy sources, the reality is that oil and gas will continue to be essential.

Before outlining the industry vision of the future and the challenges that can be overcome with technological advancements, the current role of the industry in the U.S. economy is discussed and an array of information is presented that illustrates the importance of the oil and gas industry to a strong U.S. economy.

CURRENT ROLE OF OIL AND GAS

U.S. Energy Consumption and Supply

Energy consumption increases as oil and gas supply nearly 65 percent of U.S. energy demand. In 1993, U.S. energy consumption was about 84 Quads (quadrillion BTUs), about 26 percent more than in 1970 (Figure 1-1). Oil and gas supplied nearly 65 percent of the total demand in 1993. Although the share of energy supplied by oil and gas decreased from 77 percent in 1970, the total energy supplied from oil and gas actually increased from 51 to 55 Quads in this time period.

In 1993, industrial and residential/commercial sectors accounted for about 37 and 36 percent, respectively, of end-use energy consumption.[1] Industrial sector consumption includes oil- and gas-derived feedstocks for production of high-value "petrochemicals." Transportation accounted for the remaining 27 percent of 1993 end-use consumption, with about 80 percent used to fuel cars, trucks, and buses.[2] Sixty-two percent of total oil consumption is used for

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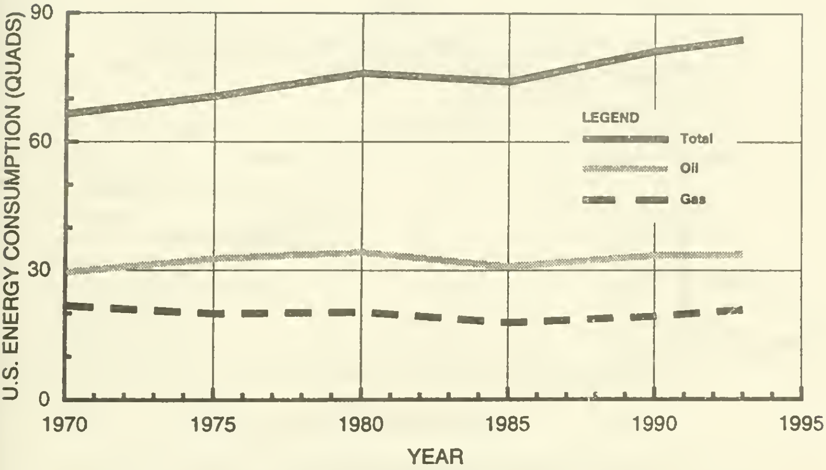
[1] Energy Information Administration, *Annual Energy Review*, 1993, p. 39.

[2] Source for fuel consumption data: Statistical Abstract of the United States, 1994, Table No. 1024.



Source: Energy Information Administration, *Annual Energy Review*, 1993, page 5.

Figure 1-1. U.S. Energy Consumption Summary: 1970-1993.

transportation. This sector is 90 percent dependent on oil and will remain so well into the 21st century.

Electricity, though a major form in which energy is consumed, is generated from primary energy sources of which coal, oil, and gas are the major foundations. In 1993, 25 percent of total U.S. energy consumption—including 3 percent of the oil and 13 percent of the gas consumed—was used to generate electricity.[3]

U.S. energy and oil & gas consumption will increase despite energy efficiency improvements. In recent testimony to Congress, Secretary O'Leary forecasted that by the year 2010 U.S. energy consumption will increase by 24 percent, and that the relative contributions of oil, gas, and other energy sources will be the same.[4]

Annual energy consumption on a per capita basis remained unchanged at about 325 million BTU during the 1970-1993 period.[5] This is despite dramatic improvements in energy efficiency, which are exhibited by a nearly 30 percent decrease in energy consumption (BTU) per dollar GDP.[6] For example, between 1970 and 1992, total fuel consumption by vehicles increased by about 44 percent while average fuel economy improved by 60 percent for cars and by 38 percent for trucks.

Domestic production provided nearly 80 percent of domestic energy demand. In 1993, domestic energy production was 66 Quads, or about 80 percent of total energy consumption (Figure 1-2). About 50 percent of the oil consumed and 91 percent of the gas were produced domestically.

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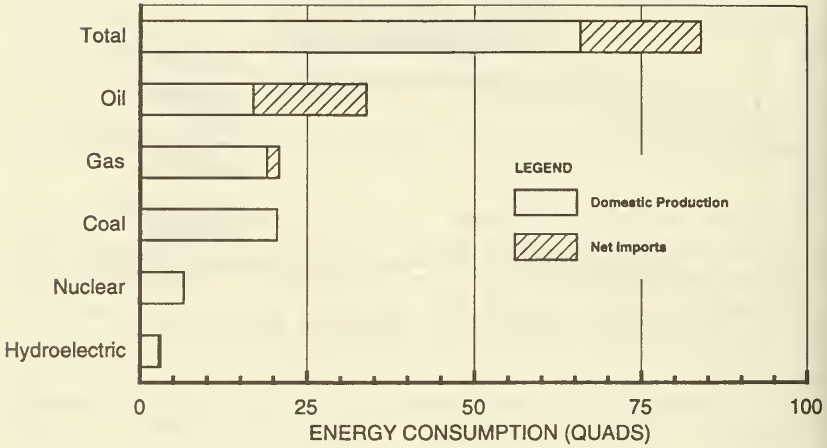
[3] Energy Information Administration, *Annual Energy Review*, 1993, pp. 5 and 237.

[4] Statement of Hazel R. O'Leary before the Committee on Appropriations, Subcommittee on Interior and Related Agencies, January 19, 1995.

[5] Statistical Abstract of the United States, 1994, Table No. 922.

[6] Statistical Abstract of the United States, 1994, Table No. 922.



Note: Net imports equal consumption minus domestic production.
Source: Energy Information Administration, *Annual Energy Review*, 1993, page 5.

Figure 1-2. 1993 U.S. Energy Consumption.

Gas imports, which came primarily from Canada, account for about 11 percent of the total gas consumption and are expected to increase to 14 percent in the year 2000. Oil imports came from a number of countries, but three-fourths of imports came from six countries (in order of volume imported): Saudi Arabia, Venezuela, Canada, Mexico, Nigeria, and the United Kingdom. (See details in Table 1-3.)

U.S. reserves of oil and gas represent a 9-year supply of U.S. production. U.S. oil and gas reserves recoverable *with current technology and at current oil and gas prices* totaled 23.7 billion barrels and 165 trillion cubic feet, respectively, in 1993.[7] At current rates of production—and with no accounting for further reserve additions—these domestic reserves represent a 9-year supply. In fact, during the 1983-1992 period, additions to U.S. reserves occurred at a rate of about 80 percent as great as production.[8]

Known worldwide recoverable reserves represent a 50-year supply. Worldwide recoverable reserves are believed to be about one trillion barrels of oil and five quadrillion cubic feet of gas (Table 1-1). At the 1993 worldwide production level of 22 billion barrels,[9] these crude oil reserves represent a 45-year supply. In 1992, 75 trillion cubic feet of dry gas was produced.[10]

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[7] Reserves data from *Oil and Gas Journal*, as reported in EIA *Annual Energy Review*, 1993, p. 287. Current production data from EIA *Annual Energy Review*, 1993, pp. 141 and 189. Reserves do not include natural gas liquids. See EIA *Annual Energy Review*, 1993, p. 129.

[8] U.S. domestic oil reserves at year-end 1983 and 1992 were 27.7 and 23.7 billion barrels, respectively. Gas reserves were 200.2 and 165.0 trillion cubic feet, respectively. In the 1983-1992 period, cumulative production of domestic oil and gas were 29.7 billion barrels and 170 trillion cubic feet, respectively. Source: Energy Information Administration, *Annual Energy Review*, 1993, pp. 129, 141, and 189.

[9] Energy Information Administration, *Annual Energy Review*, 1993, p. 291.

[10] Energy Information Administration, *Annual Energy Review*, 1993, p. 305.

TABLE 1-1

WORLDWIDE OIL AND GAS RESERVES, JANUARY 1, 1993 (Recoverable With Current Technology and Prices Except as Noted)

Country or Region	Crude Oil (Billion Barrels)	Natural Gas (Trillion Cubic Feet)
United States	23.7	165.0
Canada	5.3	95.7
Mexico	51.3	70.9
Central and South America	72.5	188.6
Western Europe	16.1	194.7
Eastern Europe and FSU	59.0	1960.4
Saudi Arabia	260.3	183.1
Other Middle East	401.5	1337.0
Africa	61.9	346.9
Far East and Oceania	44.6	341.0
World	996.1	4883.3

Note: Oil reserves for FSU (Former Sovier Union) are "explored reserves" and "gas reserves" for Canada are "proved or possible" reserves.

Source: *Oil and Gas Journal*, as reported in Energy Information Administration, *Annual Energy Review*, 1993, p. 287.

At this level, worldwide natural gas reserves represent a 65-year supply to the world.

Worldwide reserves shown in Table 1-1 represent a 50 percent increase over reserves at the end of 1982.[11] With allowance for the cumulative worldwide consumption of oil and gas during the 1983-1992 period, new reserves of oil were found at a rate 2.5 times consumption, and gas reserves were added at a rate 3.5 times consumption.[12]

The impact of technology has changed the view of the U.S. resource base over the last two decades—greatly increasing the estimates of oil and gas resources and at the same time decreasing the cost of converting the resource base to producible reserves.

There are vast U.S. oil and gas resources remaining to be discovered. Recently updated estimates of U.S. reserve extensions and "undiscovered recoverable" resources are equivalent to a 35-year supply of oil and a 59-year supply of gas at current production rates (Table 1-2).

Additional oil and gas could be recovered at a higher price or with better technology. For example, it has been estimated that advanced technology could increase domestic gas supplies in the year 2010 by about one-third over current levels, and nearly double supplies compared to those projected based on existing technology[13] (Figure 1-3).

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[11] As of December 31, 1983, worldwide crude oil and natural gas reserves were 669.3 billion barrels and 3,200 trillion cubic feet, respectively. Source: *Oil and Gas Journal*, as reported in Energy Information Administration, *Annual Energy Review*, 1983, p. 73.

[12] For the 1983-1992 period, cumulative worldwide oil production was 209 billion barrels, and gas production was 671 trillion cubic feet. Source: Energy Information Administration, *Annual Energy Review*, 1993, pp. 291 and 305.

[13] Gas Research Institute (GRI) statistics.

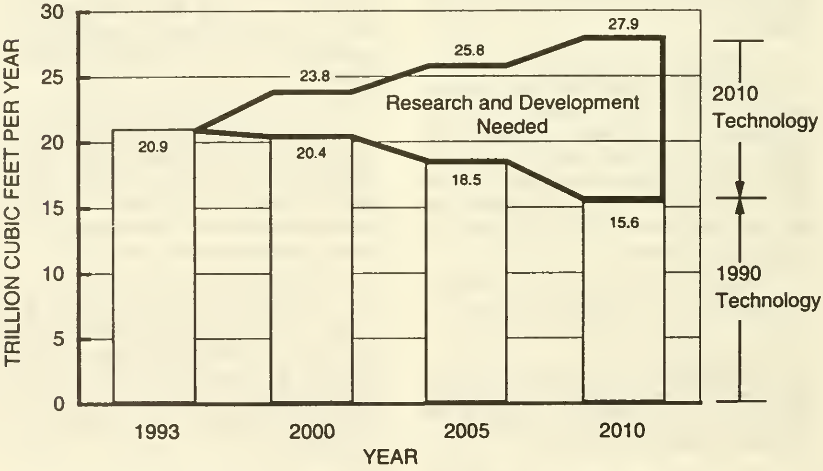
TABLE 1-2

POTENTIAL ADDITIONAL U.S. CRUDE OIL AND NATURAL GAS RESOURCES (Mean Estimates)

Region	Crude Oil (Billion Barrels)	Natural Gas (Trillion Cubic Feet)
Reserve Growth in Conventional Fields	60.0	322.0
Undiscovered Conventional Resources Onshore and State Waters	30.3	258.7
Other Accumulations	2.1	358.0
Undiscovered Federal Offshore	16.1	145.1
U.S. Total	**108.5**	**1083.8**
Years Supply at Current Rates of Production	34.7	58.9

Sources: "1995 Assessment of Oil and Gas Reserves," U.S. Geological Survey; and 1989 report of Minerals Management Service.

In addition to the above "conventional" reserves, the United States has proved reserves of oil shale and tar sand resources that are estimated to be equivalent to 560 to 720 billion and 63 billion barrels of oil, respectively.[14] It will be an economic



Source: Gas Research Institute.

Figure 1-3. Domestic U.S. Gas Supply with and without Advancing Technology.

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[14] "Fuels to Drive Our Future," Committee on Production Technologies for Liquid Transportation Fuels, National Research Council, Washington, D.C., 1990, p. 16.

advantage to U.S. consumers if the U.S. oil and gas industry assures and extends the existing worldwide conventional oil and gas resource base.

Economic Impacts of Oil and Gas

Oil imports are rising, but international trade provides an important offset. In 1993, the net cost of imported crude oil and petroleum products was about $46 billion.[15] However, the concerns that this generates should be tempered by considering the broader facts and implications. For example, the *net trade deficit* with the six largest suppliers—who account for about 75 percent of crude oil and petroleum products imports—was about $13 billion (Table 1-3).

Furthermore, in 1993 exports of organic chemicals and plastics derived from oil and gas were worth $21.8 billion, and net exports of these products were $8.3 billion.[16]

Oil and gas play a key role in the U.S. economy. A study prepared for the NPC indicates that the oil and gas industry provides the following to the U.S. economy.[17]

- 4.7 percent of U.S. gross output ($380 billion in 1987)
- 3 percent of private, nonresidential U.S. domestic investment ($22.5 billion in 1987)
- 2.9 percent of all private U.S. research and development ($2.2 billion in 1991)
- 4.3 percent of all federal, state, and local taxes ($91.9 billion in 1991)
- 84.4 percent of federal mineral lease royalties ($3.1 billion in 1993)
- 1.4 percent of U.S. employment (1.5 million jobs in 1993)
- 20.8 percent of U.S. spending on pollution abatement in manufacturing ($5.3 billion in 1992)
- Wages 14.2 percent higher than U.S. average ($30,117 vs. $26,361 in 1993)

Consumer price index data show that the U.S. economy continues to grow on the back of the oil and gas industry. In real terms, prices of crude oil and gasoline are near those that preceded the market upset of the mid-1980s (Figures 1-4 and 1-5).[18]

TABLE 1-3

SIX LARGEST SOURCES OF U.S. OIL IMPORTS, 1993

Country	Net Oil Imports (MB/D)	Balance All Trade ($Billion)
Saudi Arabia	1,408	($1.0)
Venezuela	1,281	($3.5)
Canada	1,103	($10.7)
Mexico	810	$1.7
Nigeria	734	($4.4)
United Kingdom	330	$4.6
Total	**5,666**	**($13.4)**

Sources: Net Oil Imports from Energy Information Administration, *Annual Energy Review*, 1993, p. 153. Balance of trade data from Statistical Abstract of the United States, 1994, Table No. 1329.

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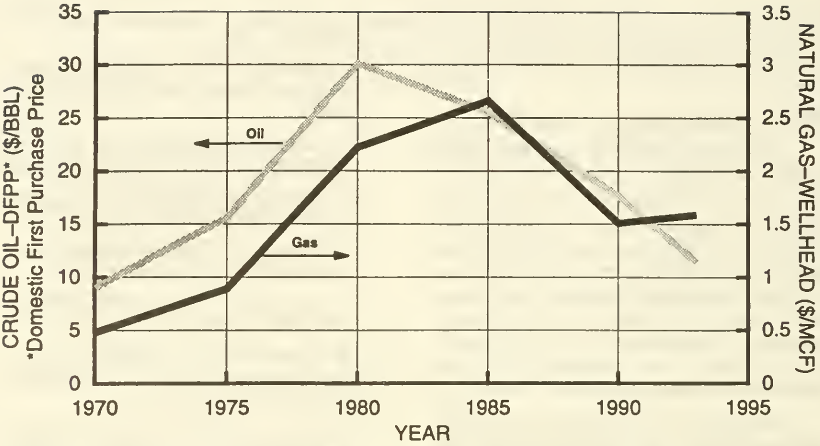
[15] Energy Information Administration, *Annual Energy Review*, 1993, p. 177.

[16] U.S. Chemical Industry Statistical Handbook, 1994, Chemical Manufacturers Association, Table 3.1.

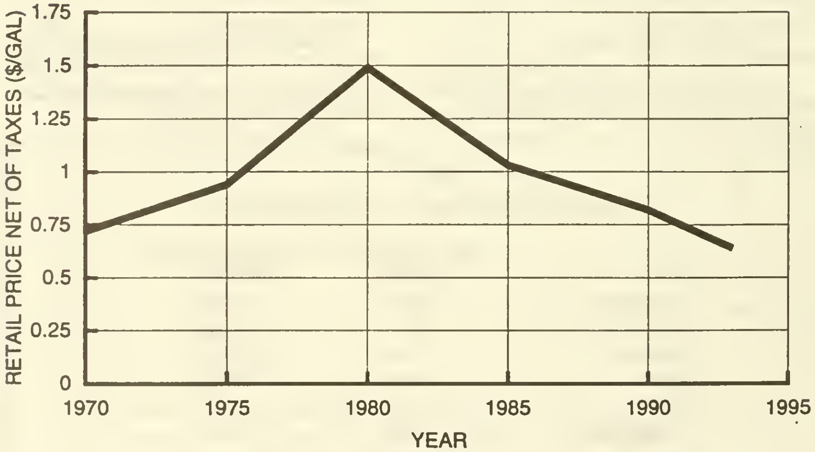
[17] National Petroleum Council, *Future Issues—A View of U.S. Oil & Natural Gas to 2020*, Appendix C, August 1995.

[18] Energy Information Administration, *Annual Energy Review*, 1993, pp. 173, 183, 203.



Source: Energy Information Administration, *Annual Energy Review*, 1993, pp. 173 and 203.

Figure 1-4. Oil and Natural Gas Prices—Summary: 1970-1993 (1987 Dollars).



Source: American Petroleum Institute, "The Cost of Motor Gasoline to Consumers", *Annual Energy Review*, 1993, Table 4.

Figure 1-5. Retail Gasoline Price—Summary: 1970-1993 (1987 Dollars).

In fact, the price of gasoline has actually declined over the past 20 years.

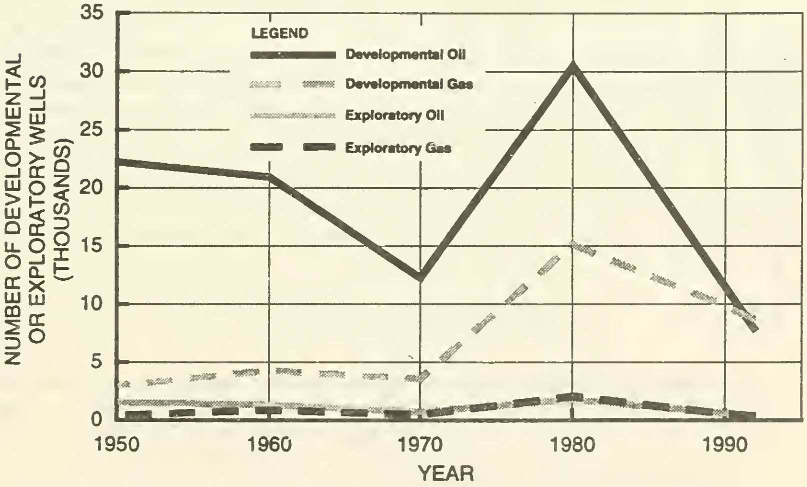
Although the overall Consumer Price Index (CPI) has increased by 75 percent between 1980 and 1993, the CPIs for fuel oil and motor fuel are at 1980 levels. The next lowest growth area—household furnishing and operation—grew 38 percent over the period.[19] These data illustrate that the growth of the U.S. economy owes a great deal to the "strong back" of the oil and gas industry.

The Domestic Oil and Gas Industry

Many of the most promising areas for oil and gas development in the United States are closed to exploration. Exploration and development activity in the United States is well down from the peak of the early 1980s (Figure 1-6). This is a result of lower oil and gas prices, but also because many of the most promising areas are closed to exploration. It is in these frontier areas that the largest discoveries are most likely. It is significant that a steadily increasing fraction of oil, gas, and coal production is on "federally administered lands" (Figure 1-7).

U.S. refining operations are technically advanced and energy-efficient. U.S. refiners have increased the technical complexity of their operations in order to achieve improved conversion of each barrel of crude oil—even as the crude oil slate has become heavier and higher in sulfur content—and as environmental restrictions have become more severe.

One gauge of this complexity is the "downstream capacity," or the capacity to process crude oil using fluid catalytic cracking, hydrocracking, hydrotreating, alkylation, reforming, and coking. Figure 1-8 shows that the ratio of downstream capacity to crude oil capacity has steadily increased. In spite of the greater complexity, between 1973 and 1990 total



Source: Energy Information Administration, *Annual Energy Review*, 1993, pp. 121 and 123.

Figure 1-6. U.S. Drilling Activity: 1950-1992.

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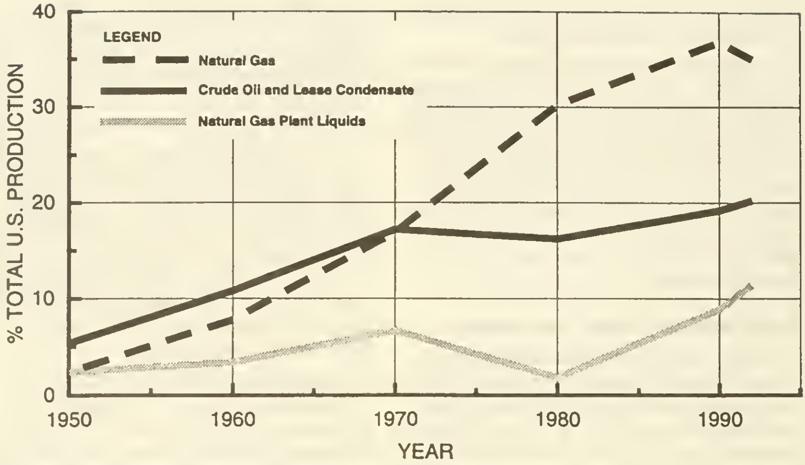
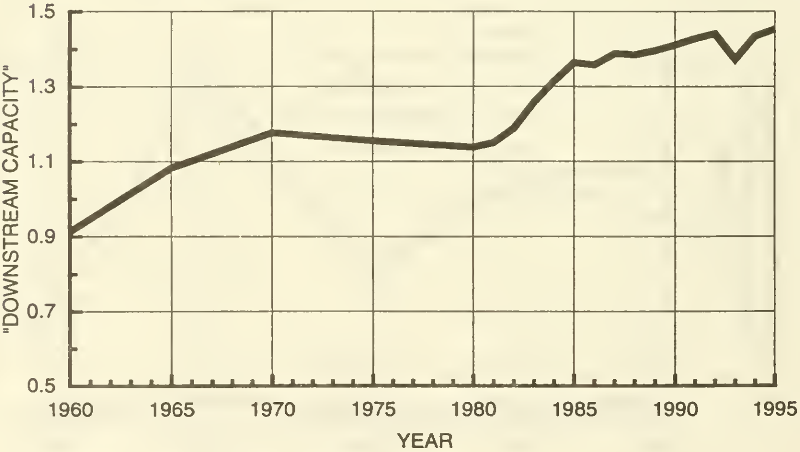
[19] Statistical Abstract of the United States, 1994, Table No. 748.



Source: Energy Information Administration, *Annual Energy Review*, 1993, p. 31.

Figure 1-7. Oil & Gas Production on Federally Administered Lands.



Source: Oil & Gas Journal Annual Surveys.

Figure 1-8. Technical Complexity of U.S. Refineries.

energy consumption per barrel of crude oil processed has been reduced by 15 percent.[20]

However, *weak margins continue to undermine profitability.* Between 1970 and 1993, the number of U.S. refineries decreased by 33 percent (Table 1-4). And the refining business has become so difficult that it is generally accepted by the industry that *no new refineries will be built in the United States.* Increased demand will be met at first through more complete utilization of existing refineries, then by de-bottlenecking and expansion of existing refineries, and ultimately by importing refined products.[21]

Refiner margins—the difference between the acquisition price of crude oil and the sale price of finished products—are below 1980 levels except in the case of fuel oil (Table 1-5). During the 1980s, refiners had an average profit of only 2.5 cents per gallon of finished product.[22] Many had operating losses. Those losses and the end of the small refiner entitlement program resulted in the closure of 132 refineries between 1980 and 1993. More efficient operations have been key to survival.

TABLE 1-4

U.S. REFINERY CAPACITY AND UTILIZATION, 1950-1993

	1950	1960	1970	1980	1990	1993
Number	320	309	276	319	205	187
Capacity (million barrels per day)	6.22	9.84	12.02	17.99	15.57	15.12
Average Capacity (thousand barrels per day)	19.4	31.8	43.6	56.4	76.9	80.9
Utilization (percent)	92.5	85.1	92.6	75.4	87.1	91.4

Source: Energy Information Administration, *Annual Energy Review*, 1993, p. 157.

TABLE 1-5

REFINER MARGINS: 1978 TO 1993
Cents per Gallon (Current Dollars), Excluding Taxes

	1980	1985	1990	1993
Motor Gasoline	27.3	19.8	25.7	23.4
Jet Fuel, Kerosene-Type	20.0	15.8	24.4	18.6
No. 2 Distillate Fuel Oil	13.4	13.8	16.6	16.8
Residual Fuel Oil	-14.0	-6.0	-11.6	-9.8
Composite	22.4	17.0	22.1	20.6

Source: Energy Information Administration, Annual Energy Review, 1993, p. 181.

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[20] "Technology Partnerships," U.S. DOE Office of Energy Efficiency and Renewable Energy, p. 54.

[21] National Petroleum Council, *U.S. Petroleum Refining—Meeting Requirements for Cleaner Fuels and Refineries*, August 1993, cover letter.

[22] National Petroleum Council, *U.S. Petroleum Refining—Meeting Requirements for Cleaner Fuels and Refineries*, August 1993, cover letter.

Regulation is dramatically increasing product costs. The NPC study on U.S. petroleum refining published in August 1993 concluded that investments in the 1990s to comply with environmental requirements on refineries and products would be $37 billion. *This exceeds the $31 billion (1993) book value of these refineries.* To recover 10 percent return on capital employed, by the year 2000 the costs to consumers of light products will have to increase by 10 cents per gallon.[23]

VISION FOR ENERGY CONSUMPTION AND SUPPLY IN 2020

Oil and Gas Consumption

Oil, gas, and coal will continue to fuel U.S. and world economies. Between now and 2020, U.S. consumption of oil and gas will increase. New technology will continue to improve the efficiency of energy utilization, but efficiency improvements will be more than offset by population growth and changes in the standard of living.

In the industrial sector, de-regulation of utilities will allow the industrial plants (including refineries) to be producers of electric power. This will result in improvement in the overall efficiency of oil and gas utilization.

Use of gas for commercial space cooling will increase because of improvements in energy efficiency and cost reductions of gas-fueled units, and because of phase-out of CFCs. Residential uses will also increase because growth in the number of customers will offset improvement in equipment efficiency and building thermal integrity.

In the transportation sector, petroleum-based fuels will continue to dominate the market, and these fuels will continue to change to meet new demands.

Advances in engine and transmission technologies, and continued vehicle weight reduction will improve fuel economy of automobiles by as much as 50 percent. However, increases in vehicle miles travelled will more than offset these improvements.

Advances made in alternatively fueled vehicles may improve uses in niche-situations. However, even if the economics and convenience of alternatively fueled vehicles (including electric vehicles) prove acceptable to consumers, inertia in fleet turnover and required investment in fuel distribution infrastructure will limit the extent of fuel substitution.

Oil and Gas Supply

Technology will be a critical component to discovery and utilization of new oil and gas resources. Major new reserves of oil and gas will be found.

Gas resources will be used to fuel local and regional economies (thereby substituting for oil), converted to liquid fuels, or marketed globally as liquefied natural gas (LNG).

Deepwater exploration and production in the Gulf of Mexico will progress rapidly during the next 10 to 20 years, primarily due to the advancements in technology and the high per-well producing rates recently confirmed. It is highly probable that the deepwater Gulf will become the primary supplier of domestic oil and gas in the very near future.

The Arctic regions of the United States will continue to be an attractive alternative to the other sources of supply of oil and gas. However, the advancements in deepwater technology will push Arctic development further back due to the high cost of development and lingering environmental concerns. The Arctic region will once again have to wait for its turn.

Oil and gas prices will remain under pressure due to continued high investment in abundant global opportunities.

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[23] National Petroleum Council, *U.S. Petroleum Refining—Meeting Requirements for Cleaner Fuels and Refineries*, August 1993, cover letter.

Refining

Refining operations will be even more technically sophisticated. Refineries will require the flexibility to accommodate changes in crude oil slates and in compositional requirements for finished products. To accomplish this, refineries will utilize "agile manufacturing" concepts. This will result in greater flexibility and improved utilization of facilities, and also will affect the size and required skill level of the refinery workforce.

New families of catalytic materials will provide the basis for major improvements in existing refining processes and will lead to the use of new chemistry and new process concepts in refining. These processes will be more efficient, more reliable, and have a much lower impact on the environment than do current processes.

The environmental impact requirements of refining products throughout the world will be similar to those in the U.S. markets. There will be minimal demand for products that do not conform to standards equivalent to U.S. standards.

New structural materials will be available that will allow operational improvements in existing processes and facilitate implementation of new processes. Nondestructive on-line testing of equipment will become widespread. Use of these techniques will dramatically reduce incident rates and maintenance costs, and will extend the useful life of plants.

Environmental remediation of refineries related to past operations should be largely completed. The new driving force for environmental performance will be "zero emissions" processes.

Response of the U.S. Industry

The U.S. oil and gas industry will be a vigorous competitor domestically and internationally. The U.S. oil and gas industry will continue to focus on its core businesses of oil and gas exploration, production, transportation, refining/processing, and marketing.

The industry will conduct business globally—exploring and developing the best prospects available—and will make investments in business sectors and geographical regions where it is possible to produce a fair return to its stockholders. In this capacity, the industry will be a strong contributor to the economic development and standard of living of nations throughout the world.

The competitive edge of the industry will increasingly depend on the ability to manage and apply technology effectively and rapidly. This will include leadership in technology for efficient investment of capital for environmentally sound operations and environmentally acceptable hydrocarbon fuels.

BARRIERS TO ENERGY SUPPLY VISION

NPC members identified a set of barriers to the vision; overcoming some will require new and improved technology. Recipients of the survey used to identify RD&D needs (see Chapter Two) were asked to describe "in broad general terms" the barriers and problems that might prevent them from accomplishing their corporate business needs and for which there might be emerging technological solutions. Sixty-seven companies responded to the question, and the responses provided separate barrier statements that were grouped and analyzed under the following four themes:

- Cost Control
- Economics and Capital Availability
- Environmental Compliance and Regulatory Issues
- Technology Transfer.

Cost Control

Twenty-five statements related to needs to reduce costs. In some cases, the statements included specific technology solutions. The barrier statements related to costs by the business activity headings used in the survey are included in Appendix D on survey results (Appendix D is Volume II of this report). The overriding emphasis and theme that was consistent throughout these statements was the desire for technology to reduce costs in the respective area.

Economics and Capital Availability

Sixteen percent of the responses relating to barriers to achieving their broad business needs related to economics and availability of capital. In general, these statements raised the concern regarding availability of capital for investment. Although it is difficult to relate this to a technological solution, since this dilemma is driven by industry profitability and a number of broad trends within the industry, the general inference is for the need of new technology to help improve success rates or lower costs that will make new investments more attractive.

Environmental Compliance and Regulatory Issues

Not unexpectedly, many of the statements related to compliance issues such as waste disposal and short lead times. There were also a group of statements about "property issues." These relate to lack of access to promising but "sensitive" exploration areas, such as offshore and Alaska, that low-impact exploration technology could affect. Statements related to downstream barriers noted that regulations had reduced the expected useful economic life of refineries, and that remediation requirements hindered alternative development of sites.

Technology Transfer

In the category of technology transfer, three areas were identified as problems or barriers to achieving broad business needs. The three primary areas noted in the statements were (1) identification of technology needs, (2) evaluation of available technologies, and (3) demonstration or application of available technologies. It is important to note that these areas were raised by a significant number of survey respondents as a barrier or problem to achieving their business needs.

SUMMARY

As the discussions of the role of the U.S. oil and gas industry and the vision of the future have indicated, this industry is vital to a strong U.S. economy. This chapter also has outlined the broad business challenges facing the industry that were identified by our survey and that could be overcome with advanced technologies. These challenges were identified and discussed in order to better understand the basis and broad parameters of the technology needs.

NPC members believe that improvements in technology are the key to overcoming many of these barriers. Therefore, identifying the specific RD&D needs of the industry is the central component of this study. Chapter Two focuses on identifying these industry needs.

CHAPTER TWO

TECHNOLOGY NEEDS OF THE INDUSTRY AND IMPACT OF TECHNOLOGY SOLUTIONS

The RD&D needs of the U.S. oil and gas industry have been assessed by the Council with the assistance of an Industry Needs Task Group consisting of representatives from industry, government, and RD&D consortia. The oil and gas industry's technology needs were determined based on a comprehensive survey distributed to a large cross-section of the industry (primary data), an analysis of other pertinent studies completed in the last several years (secondary data), and the best judgment of the Task Group to interpret the data from the first two sources. The scope of this study began with identification of the resource and ended with the output of the oil refinery and the gas processing plant.

INDUSTRY NEEDS SURVEY

A 31-page survey (see Appendix D, Volume II of this report) was developed to query the members of the National Petroleum Council about needed technology advances, the impact of these advances, and the likelihood that such advances would be commercially available in the short term (by 1999) and in the long term (between 2000 and 2010). A further purpose was to determine the degree of willingness to collaborate to advance these technologies, and to identify issues that are barriers to technical collaborations with other oil and natural gas companies, DOE, the national laboratories, and other public and private laboratories.

The survey identified and addressed nearly 250 individual technologies. Respondents also had an opportunity to write in technologies that they did not find listed and believed would have a high impact on their business performance. The survey grouped the technologies in eleven categories:

- Exploration
- Development
- Drilling and Completion
- Production
- Deepwater Offshore
- Arctic Region Activities
- Oil Processing and Refining
- Gas Processing
- Gas Gathering
- Gas Storage
- Environmental and Regulatory.

SECONDARY SOURCES

The NPC reviewed published summaries of recent petroleum RD&D priority recommendations and trends in petroleum

RD&D expenditures. They designed these reviews to provide a context in which to interpret the results of the survey and both supplement and corroborate the survey results.

First, the study participants reviewed a representative sample of more than 30 recently published oil and gas technology needs assessments and documentation of current federal RD&D programs. A detailed review of the most representative of these revealed that research priorities vary considerably among types of company and by types of technology. The diverse way these assessments characterize technology needs made a direct comparison difficult. However, the major themes of technology needs were improved resource characterization (for both exploration and development), reduced drilling costs, and improved understanding of complex reservoirs. This apparent bias toward extraction technologies is partly due to the dominance of upstream technology assessments in the literature. The reviews provided insights into how technology priorities have changed over time and differ between majors and independents.

SURVEY RESPONDENTS

The survey was distributed to NPC member companies and 89 responses were received. The response rate was approximately 75 percent, which is very high for a survey of this type. For purposes of analysis of the survey results, the respondents were categorized as majors, other integrated oil and gas companies, independents, or service companies. Statistics for these categories are given in Table 2-1. The respondents are listed by segment in Appendix D.

The 89 companies reported U.S. reserves of 11.8 billion barrels of oil and 74.6 trillion cubic feet of gas—*or about 50 percent of total U.S. reserves.* The companies also reported worldwide oil reserves of 24 billion barrels and worldwide gas reserves of 128 trillion cubic feet. The respondent companies reported sales greater than $425 billion. The respondents have 9 million barrels per day of refining capacity, which is about 60 percent of total U.S. capacity. The 20 service company respondents represent most of the upstream service companies.

METHODOLOGY FOR ANALYSIS OF SURVEY TECHNOLOGY NEEDS RESULTS

Responses to survey questions about impact of a particular technology and likelihood that it would *not* be commercially available were scored 1, 3, and 5 for "low," "medium," and "high," respectively. Then, for each technology a mean score was computed for each of the different groupings based on the short term (1995-1999) and long term (2000-2010) needs for each of the four categories of respondents listed in Table 2-1.

For each of the 11 technology areas, the technology needs were plotted using the scores for numerical impact and likelihood of commercial availability. Of most relevance to this chapter are those needs that have both a high impact and a higher likelihood of not being met (see Figure 2-1). In the figures in this chapter, these points appear in the upper right. Selected plots are included in following section on

TABLE 2-1

SURVEY RESPONDENT STATISTICS

Category	No. of Respondents
Majors	17
Other Integrated Oil and Gas Companies	12
Independents	40
Service Companies	20
Total	**89**

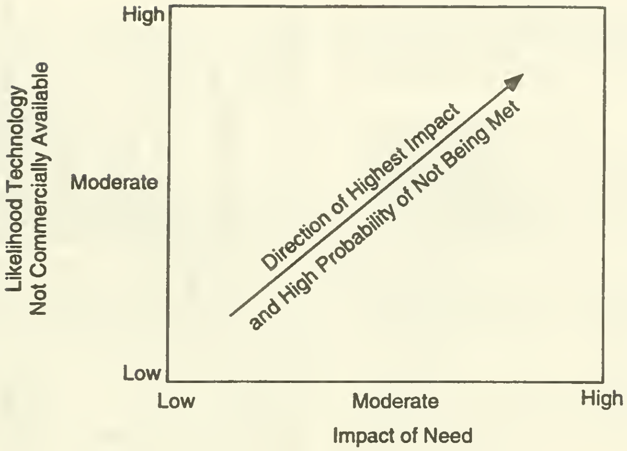

High
Moderate
Low
Likelihood Technology
Not Commercially Available
Low
Moderate
High
Impact of Need
Direction of Highest Impact
and High Probability of Not Being Met

Figure 2-1. Plotting Needs and Availability.

Key Technology Needs. Appendix D contains the additional plots for each technology area by each respondent grouping (major, independent, etc.).

KEY TECHNOLOGY NEEDS

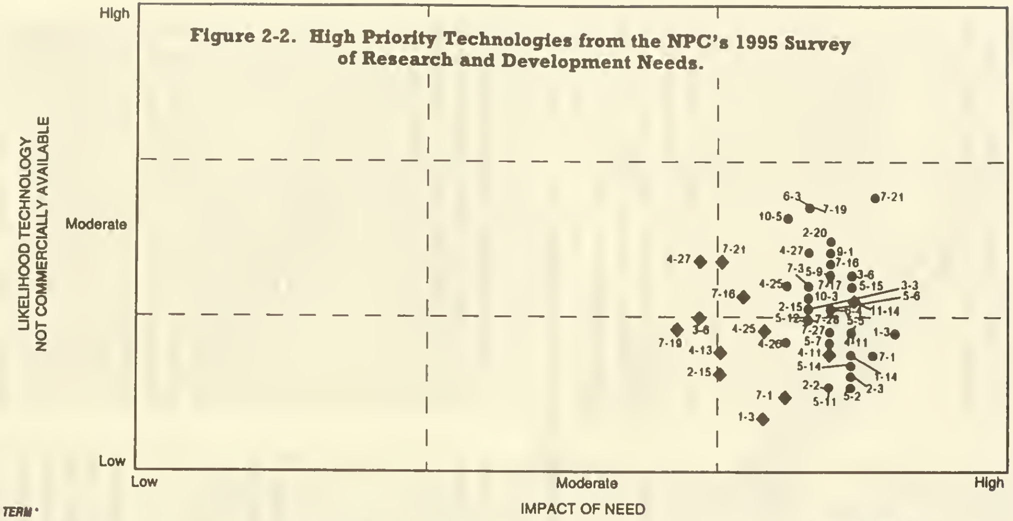
Overall

From the nearly 250 technology needs (including write-ins) across all 11 technology areas, the study participants identified 36 technology needs in which advances should have the broadest application, highest impact, and the highest likelihood of not being commercially available.

The Task Group believed that the respondents had greater confidence in judging the impact of a technology on their business than the likelihood that a technology would not be commercially available. Therefore, the impact of a technology advance on a company's business was the primary factor in ranking the need for that technology. The likelihood that it might *not* be commercially available was a secondary factor. Those needs with impact scores of 4.0 or more in the short term and 3.5 in the long term were further screened using the index: (impact x 2) + (likelihood of *not* being commercially available). There were one long-term and 35 short-term technology needs that had index scores of ten or more and were voted on by at least five respondents. These high-scoring needs were distributed across virtually all of the 11 technology areas. Figure 2-2 lists the 36 technologies and shows the plot of availability vs. impact. The needs that meet the above screening criteria, as well as needs that were written in by three or more respondents, are discussed more fully below.

Across the 11 technology areas, the highest areas of impact identified by majors, other integrated companies, and independents in the upstream are high-resolution depth imaging and improved well productivity. Hydrate control and removal also is important. Advanced seismic acquisition is a high need for independents, and horizontal well technology is the highest ranking need for service companies. In

Figure 2-2. High Priority Technologies from the NPC's 1995 Survey of Research and Development Needs.



● *SHORT TERM* *

Q.1 Exploration
- 1-3 (51) High-resolution seismic depth imaging
- 1-14 (46) Advanced seismic acquisition

Q.2 Development
- 2-2 (45) Computer-based 3D geological modeling
- 2-3 (43) Development-scale seismic applications
- 2-15 (50) Through casing logging
- 2-20 (48) Permeability logging techniques

Q.3 Drilling And Completion
- 3-3 (49) Advanced fracture techniques
- 3-6 (47) Well productivity

Q.4 Production
- 4-11 (53) Stimulation techniques
- 4-25 (49) Near well bore stimulation
- 4-26 (43) New directional drilling
- 4-27 (39) Advanced recovery of natural gas

Q.5 Deep Water Offshore
- 5-2 (20) Extended reach drilling or production
- 5-5 (12) Flowlines
- 5-6 (13) Flow metering
- 5-7 (15) Subsea equipment
- 5-9 (14) Risers

Deep Water Offshore (continued)
- 5-11 (20) Drilling
- 5-12 (11) Workover
- 5-14 (11) Hydrate prevention
- 5-15 (11) Multi-phase pumps

Q.6 Arctic Region Activities
- 6-3 (7) Development
- 6-4 (10) Drilling

Q.7 Oil Processing and Refining
- 7-1 (22) Catalysts with improved selectivities yields, lifetimes
- 7-3 (18) Plant and process reliability
- 7-16 (21) Energy efficiency of processes
- 7-17 (19) Energy efficiency of equipment
- 7-19 (14) Separations technologies
- 7-21 (10) New approaches to refining heavy feeds
- 7-27 (10) Performance characteristics of new hydrocarbon fuel compositions
- 7-26 (14) Environmental characteristics of new hydrocarbon fuel compositions

Q.9 Gas Gathering
- 9-1 (30) Compression

Q.10 Gas Storage
- 10-3 (11) Reservoir management
- 10-5 (9) Base gas minimization techniques

Q-11 Environmental and Regulatory
- 11-14 (41) Provide scientific basis for risk-based regulation

◆ *LONG TERM* *

Q.1 Exploration
- 1-3 (27) High-resolution seismic depth imaging

Q.2 Development
- 2-15 (22) Through casing logging

Q-3 Drilling and Completion
- 3-6 (28) Well productivity

Q-4 Production
- 4-11 (21) Stimulation techniques
- 4-13 (18) Recompletion techniques
- 4-25 (19) Near well bore stimulation
- 4-27 (28) Advanced recovery of natural gas

Q-7 Oil Processing and Refining
- 7-1 (14) Catalysts with improved selectivities yields, lifetimes
- 7-16 (15) Energy efficiency of processes
- 7-19 (21) Separations technologies
- 7-21 (21) New approaches to refining heavy feed

* Numbers in parentheses indicate number of responses.

the downstream, the highest needs are for improvements in catalysts, heavy feed processing, reliability, and efficiency. The environmental compliance issue also is an important crosscutting need.

Exploration

More precise characterization of the resource would have the greatest impact on exploration success. Specifically, in the short term, advances in high-resolution seismic depth imaging and advanced seismic acquisition are identified as having high impact (Figure 2-3). In the longer term, advances in high-resolution seismic depth imaging continues to be a technology need. The majors also see more impact in the long term from 3-D visualization tools and feel these needs will probably be met.

Development

The highest priority need for the development area in the short term is in better characterizing the reservoir. Improved borehole logging techniques to either estimate permeability or operate through-casing are part of this need. Away from the borehole, improved characterization of the reservoir results from improved development-scale 3-D geologic computer modeling and seismic techniques. Logging through-casing will not be adequately met in the short term and will require continued development in the long term (Figure 2-4).

Advances in characterizing fractured reservoirs was written in by a large number of respondents as a critical need. This technology need was listed in the exploration area and highly rated there, as well.

The four different groups of respondents all had the preceding needs. The greatest divergence of opinion exists between the majors and the other three groups in the long term. The majors need ongoing development of all of the technical areas identified for the short term. They may also need development of wellbore tools that have a greater depth of investigation (>1 foot) from the wellbore. The other three groups felt that their needs would be met in the short term in all areas except in the through-casing logging area.

Drilling and Completion

In the Drilling and Completion category, the two areas in which the survey participants ranked the highest RD&D needs are well productivity and advanced fracturing techniques. This is consistent with the outcome of the Production category, in which well stimulation techniques and new directional drilling are most important (Figure 2-5).

The majors also considered advances in unconventional, slimhole, and multilateral drilling to be needed. The other integrated companies added coiled tubing to their priority list. The independents also consider perforating and wellbore applications to be an important need, in addition to well productivity and advanced fracturing.

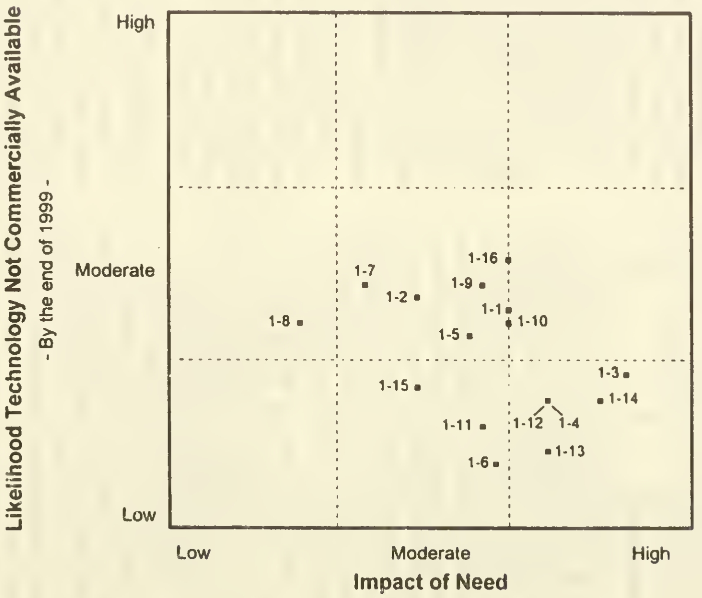
The results for the service companies were quite different from the other groups. The only technologies with significant needs are multilateral drilling, measurement-while-drilling (MWD), and horizontal wellbore applications. Fracturing and gravel pack technologies were added as a write-in by all segments except the service companies.

In the long term, well productivity is the most important technology in the category for total respondents. For independent firms and service companies, perforating and wellbore cleanup rank as the highest priority that is not considered likely to be developed.

Production

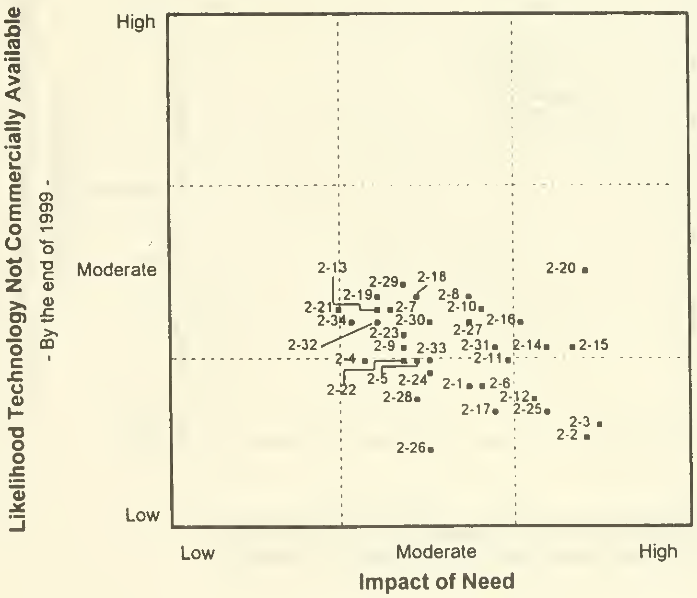
Based on the survey, the production development that will have the highest future impact is stimulation technology (Figure 2-6). This need is shared by all sectors of the industry: majors, other integrated companies, and independents. There is a moderate expectation that these needs will be met in the near term and increasing

Figure 2-3. Exploration Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



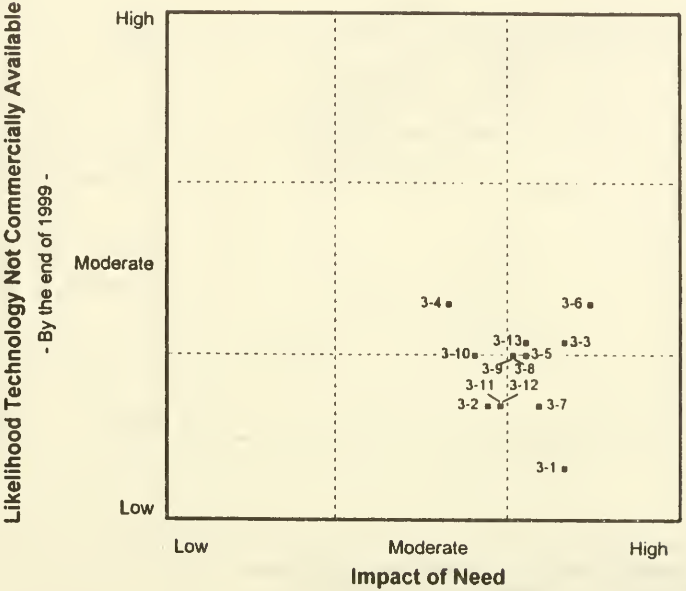
	Technology	*No. of Resp.*
1-1	3D Basin modeling	30
1-2	Risk assessment methods	34
1-3	High-resolution seismic depth imaging	51
1-4	Specialized seismic processing	47
1-5	Sequence stratigraphy techniques	42
1-6	Workstation seismic modeling	51
1-7	Geochemical analysis	30
1-8	Airborne/satellite remote sensing	21
1-9	Fault seal analysis	37
1-10	Multi-component seismic techniques	32
1-11	3D Paleostructural restoration	33
1-12	Amplitude versus offset (AVO) in 3D	52
1-13	3D Visualization tools	45
1-14	Advanced seismic acquisition	46
1-15	Geographic information systems	29
1-16	Geophysical fracture-detection methods	37

Figure 2-4. Development Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



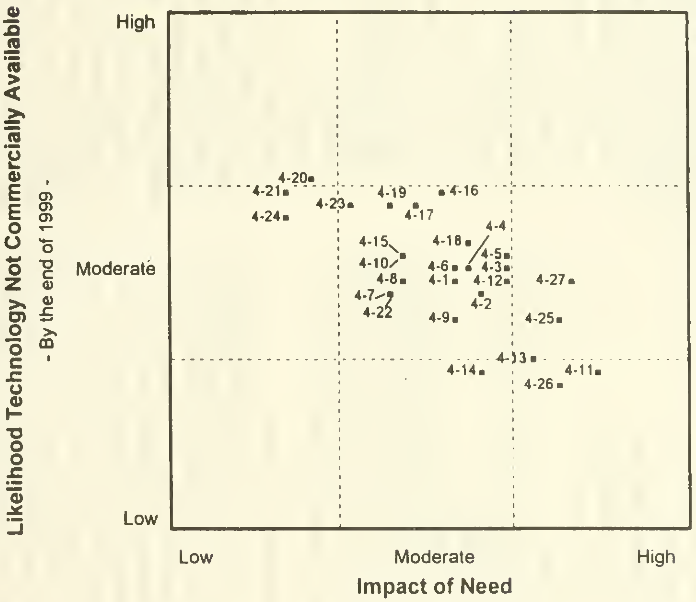
Technology		No. of Resp.
2-1	Advanced reservoir analog models	32
2-2	Computer-based 3-D geological modeling	45
2-3	Development-scale seismic applications	43
2-4	Tracers (biologic/chemical/radioactive)	24
2-5	Core analysis/imaging	35
2-6	Geostatistical reservoir descriptions	36
2-7	Outcrop analog studies	24
2-8	Fluid-rock interaction	39
2-9	Rock physics	30
2-10	Cross-well geophysical imaging	32
2-11	Advanced attribute processing	34
2-12	Seismic/log/core calibration	48
2-13	Cuttings analysis	28
2-14	Reservoir property identification	44
2-15	Through-casing logging	50
2-16	Deep investigation techniques	42
2-17	High resolution borehole imaging logs	41
2-18	Specialized core analysis	29
2-19	Characterization of rock wettability	26
2-20	Permeability logging techniques	46
2-21	Tracer techniques	23
2-22	CT scanning and NMR imaging	24
2-23	Formation water chemistry	25
2-24	Fluid sampling and analysis	31
2-25	Advanced reservoir simulation modeling	43
2-26	Workstation single well simulations	37
2-27	Procedures for data scale-up	28
2-28	Expert systems applications	20
2-29	Time lapse seismic imaging	22
2-30	Advanced monitoring of EOR processes	24
2-31	Advanced well testing and interpretation	38
2-32	Material balance applications	28
2-33	Decision and risk analysis	31
2-34	Expendable well bore instrumentation	20

Figure 2-5. Drilling and Completion Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



	Technology	*No. of Resp.*
3-1	Horizontal well bore applications	56
3-2	Drilling fluid design	45
3-3	Advanced fracture techniques	49
3-4	Cementing	42
3-5	Perforating and well bore cleanup	48
3-6	Well productivity	47
3-7	Multilateral technology	36
3-8	Innovative bit and tubular technology	42
3-9	Slim hole drilling	39
3-10	Under balanced drilling	30
3-11	Measurements while drilling	46
3-12	Coiled tubing drilling	39
3-13	Unconventional drilling technology	25

Figure 2-6. Production Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



	Technology	*No. of Resp.*
4-1	Injection water treatment	37
4-2	Produced water treatment	43
4-3	Corrosion control	48
4-4	Scaling inhibitors	51
4-5	Paraffin control/removal	48
4-6	Oil/water/gas/separation	37
4-7	Beam pump analysis	35
4-8	Gas lift analysis	33
4-9	Submersible pump analysis	35
4-10	Rod/tubing wear evaluation	38
4-11	Stimulation techniques	53
4-12	Gas compression techniques	39
4-13	Recompletion techniques	50
4-14	Remote control and data analysis	39
4-15	Compact processing on offshore platforms	25
4-16	Modification of reservoir fluid mobilities	30
4-17	Miscible contact/displacement	25
4-18	Viscosity reduction of heavy oils	24
4-19	In situ generation of foams/emulsions	20
4-20	Thickeners for CO_2 floods	18
4-21	Microbial EOR processes	14
4-22	High-velocity gas flow modeling	23
4-23	Thermal processes	22
4-24	Combustion processes	18
4-25	Near well bore stimulation	49
4-26	New directional drilling	43
4-27	Advanced recovery of natural gas	39

likelihood that the needs will be met in the long term. Advanced recovery methods for natural gas is an important need for other integrated companies and independents. New directional drilling methods will be needed in the future, but there is a general expectation that this technology will be available.

Deepwater Offshore

Deepwater offshore needs for technology advancement were prioritized in the following order in the short term (Figure 2-7):

1. Multiphase pumps
2. Risers
3. Flow lines
4. Flow metering
5. Workover
6. Hydrate prevention
7. Subsea equipment
8. Extended reach wells
9. Drilling.

Only the majors identified higher impact needs in the long term: multiphase pumps and workovers.

The write-in areas of concern concentrated on mooring systems, paraffin buildup prevention, and pipeline laying, repairing, and pigging. Remote power distribution systems and remote controls were also suggested as areas of high technology need.

Arctic Region Activities

The Arctic region activities area received responses primarily from the majors, with one or two responses from the independents and the service companies. There were no responses from the other integrated oil and gas companies. Two areas received a medium to high impact rating. They are development and drilling (Figure 2-8). These categories are very general and do not define specific areas to focus research and development. There was skepticism that the technology would be commercially available in all categories, but Arctic drilling seemed to be of less concern in the near term than the other areas.

More people responded to the long-term time frame than the short term. This could indicate that the industry believes the Arctic is a long-range frontier to be addressed after the year 1999. The impact of Arctic technology is less than the deepwater area.

Refining

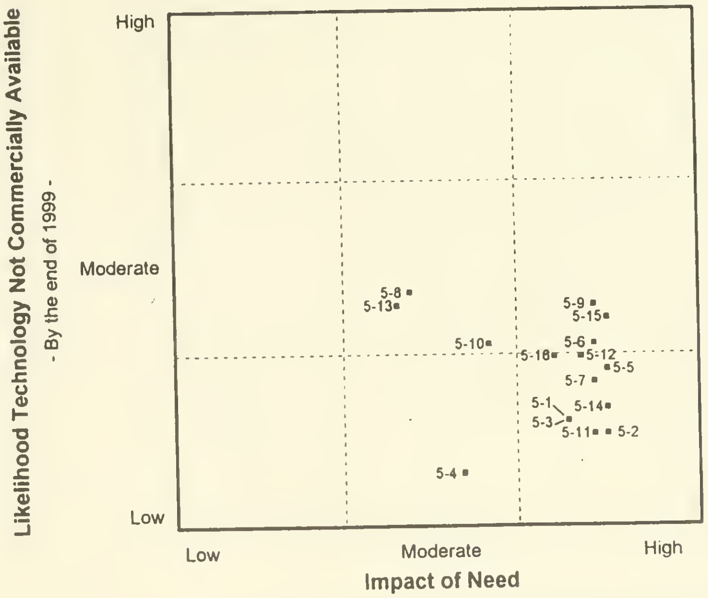
The impact of advances in technologies on the performance of the refining area is governed largely by the business environment. The majors, other integrated companies, and independents perceive that advances in the following technology areas will have major impacts on the performance of their operations in both the short term (Figure 2-9) and the long term:

- Catalysts with improved selectivities
- Plant and process reliability
- Energy efficiency of operations
- New approaches for refining heavy feedstocks
- Relating chemical composition to performance of processes and products
- Performance (including environmental) characteristics of new hydrocarbon fuels (such as future reformulated gasolines)
- Separations.

The majors tend to place greater importance on the need for advances in plant and process reliability and on the need for new processes for heavy feeds, while the independents emphasize separations technologies to a greater extent than do the majors.

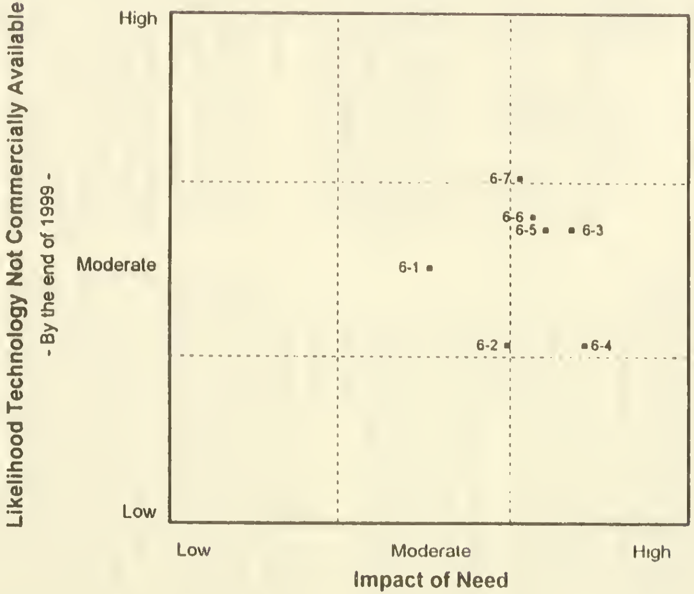
Catalysts, which have been a mainstay for refining technology, are viewed as an area that will have one of the greatest impacts but is one in which the industry is confident that successful advances will occur. On the other hand, the industry as a whole is less confident that advances in technology for energy efficiency or processing heavy

Figure 2-7. Deepwater Offshore Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



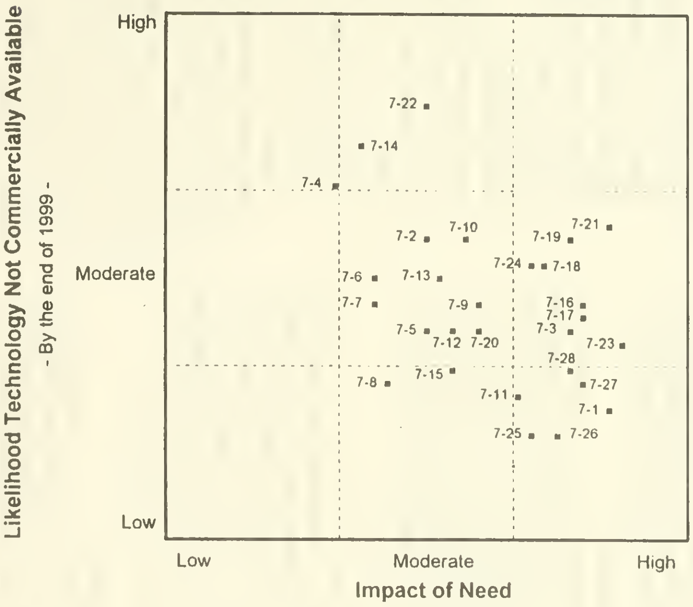
Technology		No. of Resp.
5-1	Produced fluid disposal	10
5-2	Extended reach drilling or production	20
5-3	Extended reach control systems	12
5-4	High pressure systems	9
5-5	Flowlines	12
5-6	Flow metering	13
5-7	Subsea equipment	15
5-8	External corrosion protection	10
5-9	Risers	14
5-10	ROV systems	10
5-11	Drilling	20
5-12	Workover	11
5-13	Water/gas injection	6
5-14	Hydrate prevention	11
5-15	Multi-phase pumps	11
5-16	Structures	11

Figure 2-8. Arctic Region Activities, Short Term, from the 1995 NPC Survey of Research and Development Needs.



Technology		No. of Resp.
6-1	Transportation	7
6-2	Exploration	7
6-3	Development	7
6-4	Drilling	10
6-5	Production	7
6-6	Deepwater offshore activities	5
6-7	Mobile ice	6

Figure 2-9. Oil Processing and Refining Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



Technology		*No. of Resp.*
7-1	Catalysts with improved selectivities, yields, lifetimes	22
7-2	Hydrogen production and recovery	16
7-3	Plant and process reliability	19
7-4	Unconventional process technology	3
7-5	New materials of construction	5
7-6	Reactor engineering and modeling	10
7-7	Catalyst manufacturing technology	10
7-8	Risk assessment methodology	21
7-9	Solid acid catalysts	9
7-10	Alternatives to olefin alkylation process	8
7-11	Techniques for integration of environmental solutions into process and plant design	17
7-12	Improved on-line NDE inspection technology	17
7-13	Predicting useful remaining lifetimes of aging equipment	16
7-14	Robotics for safety applications	4
7-15	Worker safety systems	21
7-16	Energy efficiency of processes	21
7-17	Energy efficiency of equipment	19
7-18	Energy efficiency of separations	18
7-19	Separations technologies	14
7-20	Determining chemical composition of crudes, refinery intermediates, and products	14
7-21	New approaches to refining heavy feeds	10
7-22	Processing synthetic fuels	3
7-23	Conversion of methane to liquid fuels	4
7-24	Relating chemical compositions to process and product performance	15
7-25	Advanced computational modeling of processes/reactions	15
7-26	Advanced control and information systems	20
7-27	Performance characteristics of new hydrocarbon fuel compositions	10
7-28	Environmental characteristics of new hydrocarbon fuel compositions	14

feeds will be commercialized in the short or long term. Reliability is a major current issue for the majors, but they believe their technology needs will probably be met in the near term.

Gas Processing

No technology from this area made the overall key technology need area. However, several are very important to the independents. The respondents ranked separation of high impurities and trace constituent areas as highest impact followed by acid gas removal and gas dehydration. This may reflect the belief that new gas sources will be higher in impurities, thus requiring more processing. A number of respondents expressed concern about hydrate control and removal. There was perceived to be a significantly higher short-term impact from advances in these technologies (Figure 2-10).

Gas Gathering

Compression improvements and multiphase metering are deemed to have the highest short-term impact and have the highest likelihood of not being commercially available (Figure 2-11). New compression improvement will have the greatest impact in the long term, reflecting the respondents' view that the needs will not be met in the short term.

Gas Storage

Well gas deliverability restoration and reservoir management ranked as high-impact technologies in both the short and long term. These are expected to be achieved by the long term. In the short term, base gas minimization techniques ranked very high reflecting the large dollar commitment required (Figure 2-12).

Environmental

Environmental requirements cut across all sectors of the industry, and compliance with regulatory requirements is a major expenditure for all participants in the industry. The one area that the industry respondents consistently ranked as having a high impact in the short term is the need for advances in improving the scientific basis for risk-based environmental assessments (Figure 2-13). The need is for environmental cleanup standards that balance the need to minimize risks to human health and ecosystems with costs and benefits of the cleanup.

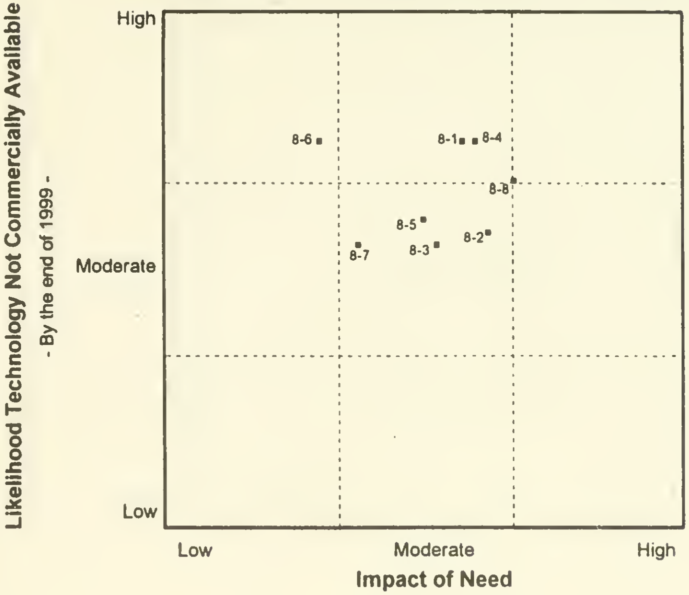
SUMMARY

The survey results indicate that there are several technology needs that the industry feels may not be met. The survey also indicates that majors, other integrated oil and gas companies, independents, and service companies have distinct technology needs. As indicated in the composite of key technology needs of the 11 technology areas, high areas of impact identified were:

- In the upstream:
  - High-resolution depth imaging
  - Improved well productivity
  - Hydrate control and prevention
  - Paraffin control (for independents)
  - Horizontal well technology (for service companies).
- In the downstream:
  - Catalysts with improved selectivities, yields, and lifetimes
  - New approaches to refining heavy feeds
  - Improved energy efficiency of processes and equipment
  - Improved plant and process reliability
  - Separations technologies.

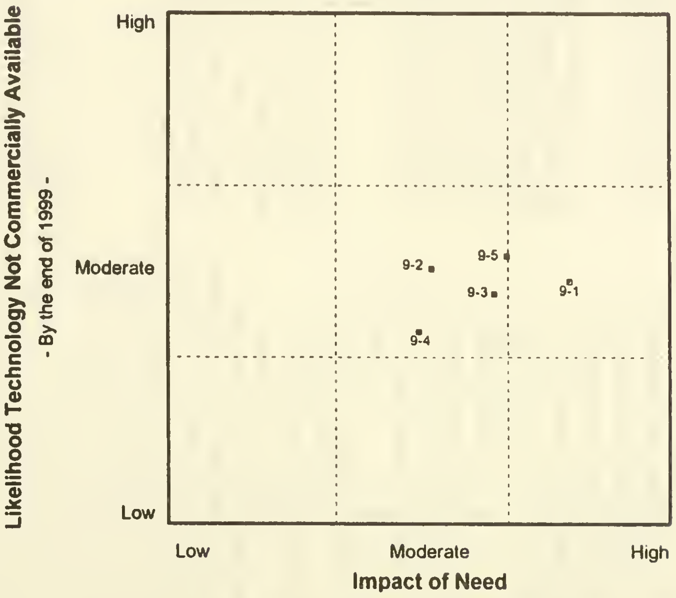
The above examples illustrate some of the highest priority distinct technology needs from the survey. Although some of the needs overlap, the priorities change with the size and type of company and with the level of research budget. The willingness to collaborate also changes by specific technology need. This chapter has needs plots for the composite of key technology needs and each of the key technology areas. Appendix D contains additional plots for the research and development needs of the industry by specific groups of survey respondents.

Figure 2-10. Gas Processing Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



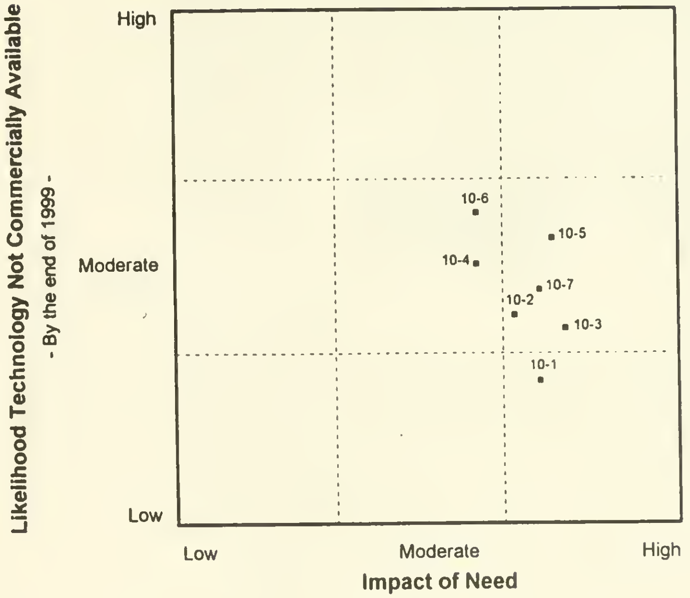
Technology		No. of Resp.
8-1	Gas dehydration	21
8-2	Acid gas removal	25
8-3	H_2S scavengar technology	23
8-4	Natural gas liquid saparation	18
8-5	Nitrogen saparation	17
8-6	Trace constituant (arsenic, Hg, atc.) removal	10
8-7	Sulfur racovery	13
8-8	Separation of high concentrations of impurities (nitrogen, CO_2, H_2S . . .)	23

Figure 2-11. Gas Gathering Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



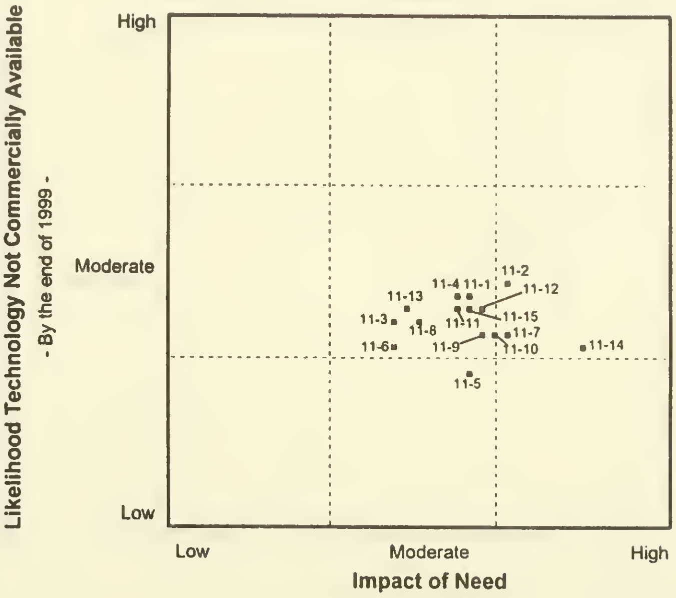
Technology		*No. of Resp.*
9-1	Compression	30
9-2	Leak detection	23
9-3	Plastic pipe (higher pressure rating)	20
9-4	High pressure measurement	13
9-5	Multi-phase metering	19

Figure 2-12. Gas Storage Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



Technology		*No. of Resp.*
10-1	Well deliverability restoration	13
10-2	Leak detection and mitigation	9
10-3	Reservoir management	11
10-4	Gas migration control	9
10-5	Base gas minimization techniques	9
10-6	Inert base gas research	5
10-7	Unconventional development techniques	9

Figure 2-13. Environmental and Regulatory Technologies, Short Term, from the 1995 NPC Survey of Research and Development Needs.



Technology		*No. of Resp.*
11-1	Disposal methods for drilling fluids	46
11-2	Treatment and disposal of produced fluids	43
11-3	Screening procedures for injection wells	27
11-4	Risk and reclamation analysis of disposal methods	41
11-5	Leak detection	40
11-6	Hydrological modeling	19
11-7	Compliance with CAAA stationary source issue	48
11-8	Advanced computation models to predict dispersion, transformation, and fate of air pollutants	28
11-9	Model transport and remediation of contaminants in ground water and soils	31
11-10	Effluent and emission monitoring, minimization, and control	43
11-11	Recycling of waste and byproduct streams	29
11-12	Remediation technology	39
11-13	Catalyst recycling	19
11-14	Provide scientific basis for risk-based regulation	49
11-15	NORM disposal	44

CHAPTER THREE

HOW LABORATORY CAPABILITIES RELATE TO INDUSTRY NEEDS

This chapter contains four sections. First is a description of the survey of the capabilities of the nine DOE national laboratories and the National Institute for Petroleum and Energy Research (NIPER) related to oil and gas industry areas of technology, followed by a discussion of the findings. Next is a section on how the laboratory capabilities align with industry needs. Finally, there are observations concerning areas for collaboration.

SURVEY OF CAPABILITIES

The oil and gas industry has traditionally worked with universities, research institutes, and service companies to develop technology, and their capabilities are well known. The capabilities of the government laboratories are less well-known to the industry and a need was felt to obtain specific information on the RD&D that the national laboratories were performing in support of the industry.

As indicated in Secretary O'Leary's original request letter to the Council, one of the key components of the programs in the *Domestic Natural Gas and Oil Initiative* is to "stimulate, facilitate, and coordinate the development and transfer of technology to the U.S. petroleum industry through technical interactions and collaborations with DOE's National Laboratories." Since analyzing the capabilities of all national laboratories was an undertaking the Council did not have the time or the resources to develop, the NPC focused its laboratory capability examination on NIPER and the following nine DOE national laboratories:

- Argonne National Laboratory
- Brookhaven National Laboratory
- Idaho National Engineering Laboratory
- Lawrence Berkeley Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest Laboratory
- Sandia National Laboratory.

These nine national laboratories and NIPER are hereafter collectively referred to as The Labs. These data do not include information on the approximately $26 million of RD&D at DOE technology centers not included in the above list.

The NPC was fortunate to obtain the assistance of the Partnership Office of the Natural Gas and Oil Technology Partnership (Partnership) in coordinating and collecting the information for The Labs. The Partnership is a part of the national laboratory system that was developed to promote interactions between the national laboratories and the oil and natural gas industry.

Data Collection Methodology

The NPC formally requested that the Partnership coordinate the collection of data relevant to laboratories' capabilities and provide their perspective on those capabilities. The NPC and the Partnership worked closely to define the types of information required to assess the capabilities of The Labs.

This information serves two purposes:

- Identifies The Labs' capabilities that relate to identified industry technology needs.
- Provides a versatile, useful catalog of The Labs' projects and capabilities.

The input from the Partnership draws upon a wealth of data submitted by The Labs. The data were compiled into the following categories, each of which appears as a separate appendix:

- *Project Summaries*: This section provides the most quantitative input in the form of one-page summaries of projects, which reflect current capabilities being applied in areas of direct interest to the petroleum industry. "Current" is defined as ongoing or active within the past five years. Total funding over the past five years (even though a project may have begun or been completed earlier) was taken as a measure of level-of-effort and capability. Each summary is tied to one or more of the 11 technology needs categories and 176 individual technologies defined by the NPC in its survey of industry needs. A standard input template and set of instructions were provided to facilitate data collection, and summary data were entered into a relational data base. The indexing of The Labs' capabilities by industry needs category represents the best judgment of the author of the project summary. A limit of approximately 50 summaries per lab was suggested to maintain a manageable size. Often The Labs combined individual projects in a way to reflect an overall capability. The data are contained in Appendix E (Volume III of this report), Part I. This appendix also contains a cross reference of the individual project summaries by technology needs category and capability index number. The table is divided into two parts. Part A is an index by primary technology needs category, and Part B is an index by individual technology needs.
- *Enabling Capabilities*: This section describes enabling capabilities or technical strengths of The Labs which have potential value, but which are not now necessarily being applied to the oil and gas industry, and thus may not be captured in the project summaries. The Labs were each given the opportunity to describe up to 20 such capabilities, but limited to six pages. Again, each capability is tied to one or more of the technology needs categories and individual technologies. The data are contained in Appendix E, Part II.
- *Historical Legacy*: The Labs were each given the opportunity to describe its "legacy" (i.e., activities predating 1991) that led to its current technology position relative to the oil and gas industry. This background information is valuable in setting the stage for the current activities described in the project summaries. This input was limited to one page. The data are contained in Appendix E, Part III.

DISCUSSION OF FINDINGS

The major purpose of the project summaries is to relate the capabilities of The Labs to the technology needs identified by industry. The Labs selected, for each project summary, a primary technology needs category. All funding for the project was assigned to this primary listing; other secondary categories could be listed if desired.

Two measures of The Labs' capabilities are the number of projects and the cumulative funding over the past five years. Table 3-1 presents the overall number of projects and total FY91-FY95 funding for the primary needs category listed for each of the 383 projects. The cumulative funding for the five-year period was about $600 million. This is equivalent to the cumulative five-year research expenditures of many individual majors. A significant portion of the $600 million represented broad capabilities rather than projects specifically directed toward oil and gas needs. We conclude that the existing effort is large enough that it deserves attention, to ensure that it is producing worthwhile results.

The Labs have significant funding and a large number of projects in the three technology needs categories of Environmental and Regulatory, Oil Processing and Refining, and Development. Together they represent 75 percent of the funding and 73 percent of the projects identified by The Labs. Total funding during the last five years for these three technical categories is nearly $450 million.

The Labs participate at a modest level in the technology needs categories of Exploration, Drilling and Completion, and Production. These three categories represent equal shares of about 18 percent of the funding of the projects identified by The Labs. Total funding during the last five years for these three technical needs categories is about $106 million.

The Labs participate at a low level in the technology needs categories of Gas Storage, Gas Processing, Deepwater Offshore, Gas Gathering, and Arctic Region Activities. These five categories represent 7 percent of the funding and 9 percent of the projects identified by The Labs. Total funding during the last five years for these five technical categories has been $42.5 million.

TABLE 3-1

NPC TECHNOLOGY NEED CATEGORY STATISTICS

	Technology Need	Number of Projects	FY91-FY95 Funding ($Million)	Funding (Percent)
1	Exploration	25	38	6.3
2	Development	68	123	20.6
3	Drilling and Completion	22	36	5.9
4	Production	23	33	5.5
5	Deepwater Offshore	7	4	0.7
6	Arctic Region Activities	2	1	0.2
7	Oil Processing and Refining	95	156	26.0
8	Gas Processing	14	12	2.1
9	Gas Gathering	6	4	0.6
10	Gas Storage	4	21	3.5
11	Environmental and Regulatory	117	171	28.5
	Totals	**383**	**599**	**100**

Individual Technologies

The data were sorted by total FY91-FY95 funding for individual technologies as a way of examining the level of oil and gas industry related activity at The Labs. Those that stand out well above the average are shown in Table 3-2. The three technology needs of Environmental and Regulatory ($53 million), Development ($42 million), and Oil Processing and Refining ($28 million) account for over 60 percent of funding for individual technologies.

Laboratory Oil and Gas Project Activity for the Past Five Years

Figures 3-1 and 3-2 show the trend of The Labs' activity in oil and gas projects over the past five years. The FY91-FY95 funding information was analyzed assuming a linear distribution of funding over a stated multi-year period and then summed by year. A strong trend of increased number of projects (>100 percent) and funding (>250 percent) between 1991 and 1995 is clearly evident. This reflects the strong push by DOE and The Labs for increased participation with industry, and the oil and gas industry in particular.

Maturity Statistics by Category

A maturity index was provided for each project summary, ranging from Basic Research (1) through Applied Research (3) and Development (5) to Ready-to-Use (7). The latter typically means demonstration, but sometimes means deployment. The Labs were allowed to respond with a single index or a range of numbers. In the analysis, both the number of projects and funding is distributed over the specified maturity index or range for each of the 11 technology needs categories (i.e., if a range of 2 to 5 was given, a quarter of the project and of the funding was assigned to each index value of 2, 3, 4, and 5). The results are presented in Tables 3-3 and 3-4. Figures 3-3 and 3-4 show the overall distribution. While interpretation of the data is subjective, we conclude that the majority of The Labs' focus is on applied research rather than basic research or technology deployment.

HOW LAB CAPABILITIES MATCH INDUSTRY NEEDS

It is clear that The Labs have outstanding RD&D capabilities in many energy-related technologies. The key issue to address is what are the best roles for The Labs in partnership with the oil and gas industry. There are a number of factors to consider including the current activities. The roles need to be consistent with the long-term missions of The Labs and the needs of the industry. Also, the impact on research efforts at universities or private research organizations should be carefully considered.

An area of mutual benefit between The Labs and the oil and gas industry is the area of "dual use." The Labs have developed very extensive capabilities in conjunction with their missions in national security. These resources are used infrequently by the oil and gas industry, but are unique and therefore invaluable when needed. A good example is the technical capability in the area of high explosive/shaped charge design that exists at Sandia, Livermore, and Los Alamos. Livermore's High Explosive Research Facility is a unique capability in this field. Joint projects using technology developed at the laboratories have made the oil and gas industry both more efficient and safer. The numerical methods developed for efficient use of parallel computers to solve national security problems have direct application to the oil and gas industry and this is another example of "dual use."

The role of The Labs in more applied projects is quite varied and not so well-defined. We agree with and quote from the Galvin task force report: "Alliances with the industrial users of the technology will be critical. RD&D produces knowledge, but the implementation of that knowledge

TABLE 3-2

INDIVIDUAL TECHNOLOGY FUNDING IN THE LABS

Technology	Needs Reference*	Funding FY91-FY95 ($Million)
Exploration		
Geographic Information Systems	1 - 15	$10.4
Specialized Seismic Processing	1 - 4	$ 9.9
Development		
Cross Well Geophysical Imaging	2 - 10	$22.8
Advanced Reservoir Simulation Modeling	2 - 25	$19.5
Drilling and Completion		
Slim Hole Drilling	3 - 9	$ 7.0
Cementing	3 - 4	$ 5.7
Production		
Corrosion Control	4 - 3	$ 8.7
Microbial EOR Processes	4 - 21	$ 5.6
Deepwater Offshore		
Structures	5 - 16	$ 2.7
Risers	5 - 9	$ 1.4
Arctic Region Activities		
Development	6 - 3	$ 1.1
Oil Processing and Refining		
Catalysts with Improved Selectivities, Yields, Lifetimes	7 - 1	$23.4
Process and Plant Design	7 - 3	$14.7
Gas Processing		
Acid Gas Removal	8 - 2	$ 7.4
Natural Gas Liquid Separation	8 - 4	$ 1.9
Gas Gathering		
Multi-phase Metering	9 - 5	$ 1.2
Compression	9 - 1	$ 0.9
Gas Storage		
Unconventional Development	10 - 7	$16.5
Leak Detection and Mitigation	10 - 2	$ 1.1
Environmental and Regulatory		
Remediation Technology	11 - 12	$30.4
Effluent and Emission Monitoring, Minimization, and Control	11 - 10	$22.3

* Refers to technology need designation in the NPC survey.

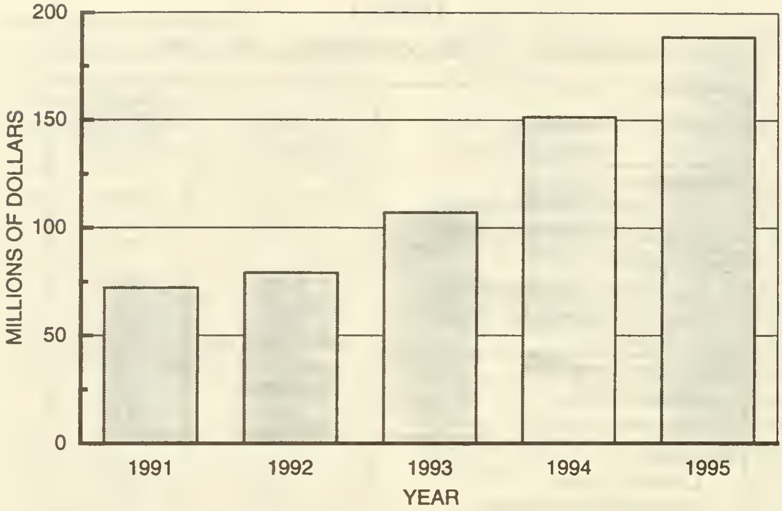


Figure 3-1. Total Funding by Year.

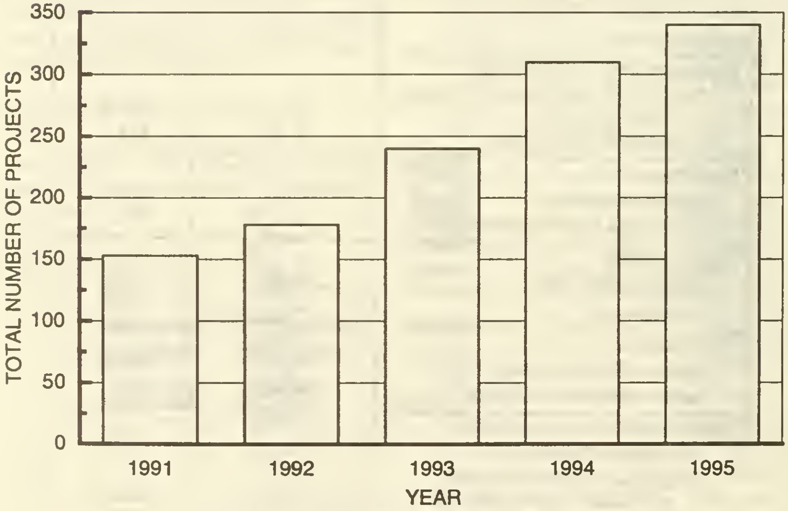


Figure 3-2. Number of Active Projects by Year.

TABLE 3-3*

MATURITY STATISTICS BY TECHNOLOGY NEED—PROJECT DISTRIBUTION (Number of Projects)

Technology Need	One	Two	Three	Four	Five	Six	Seven	Total
Exploration	1.6	3.9	8.4	3.7	4.3	2.0	1.0	25
Development	4.2	3.9	15.0	12.2	17.4	7.6	7.7	68
Drilling and Completion	0.0	0.7	4.0	5.0	7.3	2.7	2.4	22
Production	0.5	1.4	7.7	4.9	3.9	2.5	2.2	23
Deepwater Offshore	0.0	0.0	0.9	1.4	1.9	1.7	1.2	7
Arctic Region Activities	0.0	0.0	0.0	0.0	1.0	0.0	1.0	2
Oil Processing and Refining	7.0	7.5	25.5	11.5	28.0	8.5	7.0	95
Gas Processing	2.0	1.3	1.3	3.8	3.4	2.3	0.0	14
Gas Gathering	0.0	0.0	0.0	0.5	3.5	0.5	1.5	6
Gas Storage	0.0	0.0	1.5	0.5	0.5	0.5	1.2	4
Environmental and Regulatory	1.7	4.7	19.7	10.9	39.0	24.9	16.1	117
Totals	17	23	84	54	110	53	41	383

*Maturity Index — One = Basic Research. Seven = Ready to Use.

TABLE 3-4*

MATURITY STATISTICS BY TECHNOLOGY NEED—FUNDING DISTRIBUTION (Millions of Dollars)

Technology Need	One	Two	Three	Four	Five	Six	Seven	Total
Exploration	1.5	2.7	7.3	6.0	9.7	6.6	4.2	38.0
Development	2.7	5.8	23.0	21.3	31.4	18.0	21.3	123.3
Drilling and Completion	0	0.7	3.4	5.2	17.5	4.5	4.1	35.5
Production	1.4	2.3	7.7	5.1	5.8	5.8	5.0	33.0
Deepwater Offshore	0	0	0.9	1.2	1.3	0.4	0.4	4.2
Arctic Region Activities	0	0	0	0	1.1	0	0.1	1.2
Oil Processing and Refining	11.3	11.2	33.5	17.1	56.1	16.8	9.6	155.7
Gas Processing	3.8	0.6	1.0	1.7	4.3	0.9	0	12.3
Gas Gathering	0	0	0	0.4	2.4	0.4	0.7	3.9
Gas Storage	0	0	4.2	4.1	4.1	4.1	4.4	21.0
Environmental and Regulatory	1.2	3.6	25.6	10.9	55.6	45.8	28.0	170.7
Totals	21.9	27.0	106.6	73.1	189.3	103.1	77.8	598.8

*Maturity Index — One = Basic Research. Seven = Ready to Use.

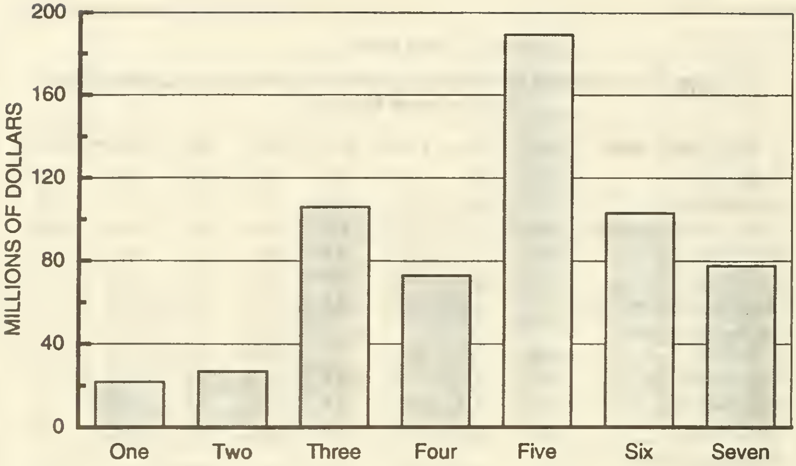


Figure 3-3. Project Funding by Maturity Index.

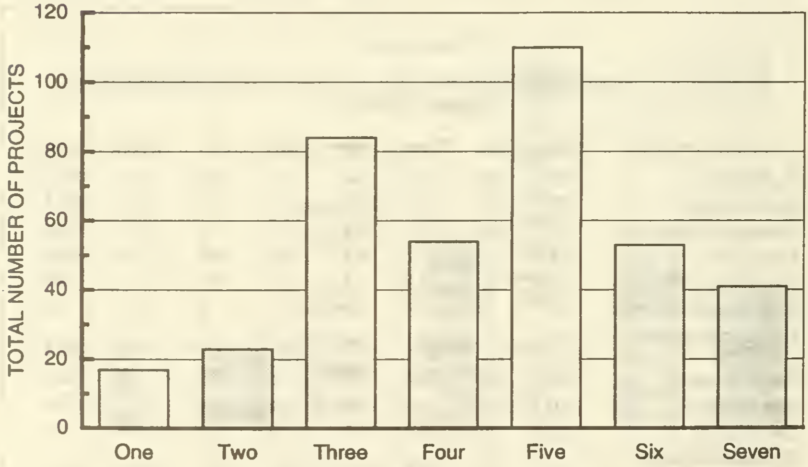


Figure 3-4. Number of Projects by Maturity Index.

in plants and products must be done by industry. If industry is not intimately involved in the planning and development of that knowledge, they will be slow to implement it if they do so at all."[1] The next section of this chapter will look at the combination of factors that must be considered to determine what are good program areas and projects for The Labs in conjunction with the oil and gas industry.

Methodology of Survey Analysis

To determine the alignment between the industry needs and the capabilities of The Labs, several criteria were developed to help understand the data. The most important factors are the industry assessment of the impact of technology, the willingness and ability of The Labs and industry to collaborate, the size and objectives of past and existing Lab projects, and the enabling capabilities of The Labs. The judgment and experience of the study participants are important factors in validating and interpreting the data.

These criteria were used in combinations to serve as screens to analyze the data. In one approach, a list of projects that would have highest impact on our business in the short and long term was identified. In this example, Lab funding levels and numbers of Lab projects were used to measure the level of effort in the laboratories. The project descriptions and enabling capabilities were used to help assess the quality and value of the work performed.

Another approach was to look for areas of high funding and compare the list with industry ranking of impact and willingness to collaborate with The Labs. It was assumed that the independents would collaborate in conjunction with the service companies. Again, the project description and enabling capabilities were used to assess the quality and value of the work.

Results of Survey Analysis

The analysis identifies several areas that are good fits for partnership, as well as highlights some areas where large expenditures by The Labs are not aligned with industry needs. It also revealed high-impact technology areas with very small project effort by The Labs. Several conclusions resulted and are contained in the following list.

1. *There is a good match between existing Lab projects and industry needs in several individual technology areas.* This is indicated by high-impact ratings coupled with a desire to collaborate with The Labs. The projects with highest impact and those with large funding are discussed below:
   - High-resolution seismic depth migration technology — Advances in this technology are highly valued by industry and take advantage of strong computational capabilities of The Labs.
   - Specialized seismic processing — The high level of industry interaction in most of these projects is somewhat surprising given the lower interest in collaboration shown in the needs survey. There are other industry sources for some of this technology; therefore, a continued high level of industry participation should be a key criterion for renewal of these projects.
   - Computer based 3-D geological modeling — Improvements to this technology take advantage of geotechnical and computational strengths of The Labs.
   - Development-scale seismic applications — Computational and theoretical capabilities of The Labs are important to the success of these projects, which have been reviewed and approved by industry through

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[1] Secretary of Energy Advisory Board, Task Force on Alternative Futures for the Department of Energy Laboratories, *Alternative Futures for the Department of Energy National Laboratories*, February 1995.

the Advanced Computational Technology Initiative (ACTI). The service industry's participation will expedite the commercialization of results.

- Advanced fracture techniques — The Lab projects in this area are done as part of Gas Research Institute studies. Strong industry input validates both the value of the work and the technical fit of The Labs as partners.
- Well productivity — Significantly improved well productivity is extremely important if the industry is going to supply the hydrocarbon demand. These projects received industry review and approval as part of the Partnership program.
- Cross-well seismic imaging — The industry recently made a decision to move from a proprietary to a collective mode to develop technology in this area. The Labs responded to the industry need by participating as an active partner. Several projects received industry review and approval as part of the Borehole Seismic Forum, a technology area of the Partnership program.
- Plant and process reliability — Several of The Labs' projects take advantage of strengths in materials, corrosion, and a large project dealing with safety and reliability of the Advanced Neutron Source. The funding amount that is directly related to industry needs is probably overstated, but The Labs' work is valuable and has industry participation.
- Energy efficiency of equipment — This area takes advantage of Lab strengths in materials and corrosion and seeks to apply the technology to oil and gas industry needs.
- New approaches to refining heavy feeds — This is a very important area for refining, both today and in the future. Lab projects target industry needs and there is good industry participation. The projects take advantage of the wide variety of The Labs' capabilities including process engineering, computational modeling, and characterization methods of heavy feeds and syncrudes.

2. *The Labs had limited projects in production stimulation, and they were not seen to be addressing the kind of breakthrough that is needed.* Production stimulation has high-impact potential and industry indicates a willingness to collaborate with others including The Labs. There is one Lab project in this area that dealt with the use of very-high-power microwaves to change permeability characteristics of the reservoir. Projects that fit this category should be reviewed carefully.

3. *There were several technology areas that were identified by industry as having the potential for high impact for which there is little effort by The Labs.* Examples of where effort by The Labs is lacking are extended reach drilling, subsea systems, multi-phase equipment, performance and environmental characteristics of new hydrocarbons, and conversion of methane to liquid fuel. The lack of effort in these areas is consistent with the lack of relevant Lab enabling capabilities at The Labs and the ability of the industry to develop these technologies collectively outside of The Labs. The Labs should not be heavily involved in these areas, and they are to be commended for not duplicating industry efforts. Other technology areas include: through-casing logging, permeability logging techniques, near wellbore stimulation, new directional drilling techniques, advanced recovery of natural gas, deepwater drilling, deepwater workovers, hydrate prevention, Arctic drilling, gas compression, gas storage, reservoir management, and base gas minimization. In some of these, The Labs appear to have the relevant capabilities for RD&D.

4. *A few projects consume large resources in the laboratories and unnecessarily duplicate efforts in the private sector.* Examples are geographical information systems and catalysts with improved selectivities, yields, and lifetimes. Continued participation in these projects should be reviewed.

5. *The appropriateness of The Labs' involvement in alternative gas storage technology is questionable.* While there is a large project for geotechnical support to the Strategic Petroleum Reserve, it does not imply that The Labs should perform RD&D in the area of alternative gas storage.

6. *Careful review of the relevance of several energy efficiency programs to industry needs is required.* With the exception of the research on high performance, compact evaporators and condensers, projects in the energy efficiency category dealt principally with advanced bioreactor concepts and improved efficiency of equipment for the paper and pulp industry. The oil and gas industry is looking for more efficient processes, particularly in the area of light gas streams containing hydrogen.

7. *Better interaction between industry and The Labs will be required to tailor RD&D separation technologies research to fit the need.* The major portion of The Lab effort ascribed to this area comes in the form of strengths in analytical chemistry. Other projects look at magnetic and membrane separation technologies.

8. *There is a need is for a scientific basis for environmental cleanup standards that balance the need to minimize risks to human health and ecosystems benefits with the costs of cleanup.* Providing the scientific basis for risk-based regulation was identified as having high impact by the industry coupled with a strong interest in collaborative development of the technology. There were several Lab projects with large funding that were classified as belonging to this subtopic, which did not appear to address industry concerns but were directed towards improved analytical methods. The enabling capabilities of The Labs indicate that projects that much more closely meet industry needs should be possible.

9. *Projects dealing with fluid forces on risers and deepwater eddies take advantage of the theoretical and computational competencies of The Labs.*

10. *The Labs do not conduct large projects to develop new production systems or techniques for Arctic development.* The funding assigned to this area was two studies conducted for the state of Alaska addressing several industry issues, rather than for production system RD&D.

SUMMARY

There is considerable interest within the oil and gas industry to expand collaborative RD&D projects to develop oil and gas technology. Industry will work with the Department of Energy to ensure that government policy serves to enhance and enable this collaboration rather than impede or compete with industry efforts.

The Labs are not and should not become the national research and development organization for the oil and gas industry. They should not become engaged in assisting the oil and gas industry to develop technology in all of the areas that were designated as high-impact and amenable to collective technology development. A good example is The Lab decision not to become engaged in the development of subsea production and extended reach drilling systems. The Labs should become involved in an area only if the competence of the laboratory already exists and if there is clear industry consensus that private sector sources for the technology are not adequate.

To quote from the Galvin task force: "The Department of Energy should move to strengthen its efforts in fundamental science and engineering, both at the laboratories and in the universities."[2] We agree that this is a very appropriate role for The Labs. This can be accomplished by increasing industry input rather than increased funding. The relevance and impact of this research can be maximized by industry review and guidance as well as industry participation. The results of this effort should be made available to all U.S. industry. There are a number of areas where The Labs have made substantial accomplishments including areas of high-energy physics, atomic and nuclear physics, biomedical science, material science, fusion energy, and computational science. In many of these areas, the oil and gas industry has benefited either directly or indirectly.

There are ongoing programs that use the unique *facilities* that are available at The Labs. These joint projects with the oil and gas industry enable leading edge research to be conducted in a variety of areas. For example, Brookhaven's National Synchrotron Light Source and the High Flux Neutron Beam Reactor have been utilized in programs involving synthesis and characterization of molecular sieves. Similarly the pulsed neutron source at Argonne has been used in joint projects with the oil and gas industry for a number of material properties projects involving hydrocarbons and zeolites. Other unique facilities include Livermore's high-powered lasers, Sandia's combustion research facility, Los Alamos' LAMPF accelerator, and Berkeley's Advanced Light Source. Projects that utilize these facilities represent an excellent match between meeting the research needs of the oil and gas industry and the mission of The Labs. These types of projects should be continued with the strong endorsement by DOE and industry.

The Labs are a partner of choice in the collaboration to develop technology in areas that are computationally intensive. The ACTI program was established to take advantage of this capability and is a positive step toward becoming industry-driven as a result of beginning to change the project proposal and prioritization system. Participation in the computationally intensive multi-phase, multi-component flow modeling in the Deepstar Project is another good example.

The projects that were identified as "good matches between industry technology need and lab capabilities of The Labs" contained in the prior section should serve as examples of the oil and gas applied RD&D projects in which The Labs should be engaged.

The Labs played a constructive role in helping the industry respond to the decision that cross-well imaging technology would be developed collectively and shared rather than as proprietary technology by companies separately. This is an example of The Labs reacting to an industry request to become a focal point for industry collaboration. The evolution of this project should be considered as The Labs seek ways to become more industry needs driven.

In accordance with the recommendations of the Galvin task force, The Labs should maintain a technology development effort in the areas of environmental technology that impact the oil and gas industry. The enabling capabilities of The Labs are strong in the environmental area, and staff appear to be very interested in this technology.

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[2] Secretary of Energy Advisory Board, Task Force on Alternative Futures for the Department of Energy Laboratories, *Alternative Futures for the Department of Energy National Laboratories*, February 1995.

CHAPTER FOUR

DEVELOPERS AND SUPPLIERS OF ADVANCED TECHNOLOGY

As discussed in Chapter Two, there are high-impact technologies that the oil and gas industry believes will *not* likely be available when needed. This situation will be discussed in terms of the process by which technology becomes available to the oil and gas industry, the traditional and new roles of industry and others in this process, and the forces that have led to changing roles. Although the discussion of capabilities in Chapter Three focused on the capabilities of The Labs, the oil and gas industry has traditionally worked with universities, research institutes, service companies, and other national laboratories to achieve the research and development needs of the industry. The roles of these institutions and oil and gas company research facilities are an integral component of delivering the research and development needs of the industry. This chapter will focus on the changing roles of all these developers and suppliers of advanced technology.

For purposes of this discussion, the term "technology developers" will refer to organizations that are capable of oil- and gas-related research, development, and demonstration. There are numerous developers. Within the industry, the major oil and gas companies and the larger service companies operate their own research facilities. As described in this chapter, private research organizations, universities, and government laboratories also have relevant capabilities.

The term "supplier" will be used to describe organizations that participate in technology "deployment," the process by which new technology is put to use in an operating setting. Suppliers generally are in-house departments of an operating company, or service companies or vendors who provide services or materials for a fee.

CHANGES IN DEVELOPERS' ROLES

In-house technology developers—like the oil and gas industry itself—are in a state of transition that has been brought on by the collapse of oil prices in the 1980s and the expectation of constrained oil and gas prices in the foreseeable future. Besides the direct pressures on in-house developers created by oil prices and resulting requirements for cost reduction, there are other indirect pressures that have resulted in a greater proportion of short-term and technical service-type activities.

Pressures on In-House RD&D Organizations

Basic research has been under pressure because of the long-term investment it represents. In addition, RD&D aimed at regulatory compliance has displaced some potentially more productive efforts.

Even the majors recognize that they cannot justify large RD&D efforts unless they can effectively leverage their investments in technology. The largest gas producer in the U.S. accounts for only about 5 percent of domestic production, and the largest oil producer accounts for less that 10 percent. Therefore, there is increased effort to get economic return on proprietary technology through licensing or technology exchanges.

Service companies continue to support research and development to differentiate themselves from competitors and to gain market share. These companies have responded to the economic realities of the oil and gas industry by refocusing their efforts to the near term. Also, there have been several recent mergers of service companies.

The smaller producers (independents)—who account for about 60 percent of the natural gas production and over 40 percent of liquids production—have not invested in technology development in the past, and are not expected to do so in the future. Independents depend on majors and service companies to develop and on service companies to supply the advanced technology used in their operations.

Trends in Oil and Gas RD&D Expenditures

Table 4-1 presents survey data on oil and gas industry expenditures for RD&D. These data represent the aggregate industry response to Survey Question 13, which asked about levels of RD&D expenditures for years 1990, 1994, and 1998.

Table 4-1 shows that in nominal dollars, total expenditures reported were $2.4 billion in 1994 vs. $2.6 billion in 1990. This reduction of *only* $200 million appears to be somewhat inconsistent with the many public and private reports of significant reductions in RD&D budgets and staff over this same time period. Even when expressed in constant dollars, the reduction is 19 percent. However, the R&D Needs Task Group believes that reductions in expenditures have been somewhat greater than these data suggest.

Table 4-2 shows trends in RD&D expenditures among the oil and gas industry sectors. The data indicate that the majors account for the largest fraction of the industry's RD&D expenditures, although their proportion has been reduced from 77 percent in 1990 to 67 percent in 1994. In contrast, service company expenditures are now 31 percent of the total in 1994, compared to 22 percent of the total in 1990. The data also confirm that the other integrated oil and gas companies and the independent producers provide limited funding of RD&D.

Respondents were asked to identify the percentage of total RD&D expenditures allocated to only oil, only gas, and both oil and gas. The distribution reported was virtually the same for 1990 and 1994: 70 percent of the investment in RD&D was directed at both oil and gas applications; 22 percent of expenditures were directed at primarily oil applications; with 8 percent of expenditures directed at primarily natural gas operations. The respondents reported that the projected distribution of expenditures in 1998 will be similar to those of 1990 and 1994.

Implications

The implications for technology development of the reduction in RD&D expenditures is not clear at this time. Industry leaders view the reduction as simply a reflection of achieving greater efficiency in

TABLE 4-1

RD&D EXPENDITURES OF THE OIL & GAS INDUSTRY*
Billions ($1990)

	1990	1994	1998
All Respondents	2.6	2.4	†
Respondents Submitting Expenditures for All Three Years	1.7	1.6	1.7

* Additional RD&D expenditures for oil and gas technology (not part of the survey)
GRI (private sector funds): $50 million/year directed at natural gas operations
DOE (public sector funds): $100 million/year directed at natural gas and oil operations.

† Some survey respondents did not submit a 1998 estimate.

TABLE 4-2

RD&D EXPENDITURES OF RESPONDENTS BY INDUSTRY SECTOR
($Millions)

	1990		1994	
	Expenditures	Percent (%)	Expenditures	Percent (%)
Majors	2004	76.6	1638	67.4
Service Companies	572	21.9	742	30.5
Other Integrated	35	1.3	42	1.7
Independents	4	0.2	7	0.3
Total	**2615**	**100.0**	**2429**	**100.0**

research programs. This argument points to the refocusing of in-house RD&D on the technology needs with highest impact, the effective use of computers and research instrumentation that was not available even a decade ago, and more effective leveraging of funds, including use of research consortia research.

In contrast, other industry leaders argue that the reduction in RD&D expenditures will constrain the long-term prospects of the oil and gas industry. The arguments here point to a reduction in basic research, an apparent focus on low-risk, short-term research, and significant reductions in research and engineering staffs. There is a

Paradigms for Industry RD&D

	OLD PARADIGM		NEW PARADIGM
Source of Technology:	In-House	———>	Leverage & Collaborate
Project Prioritization:	Technology Push	———>	User Needs
Motive:	Own It	———>	Use It

view that the underlying reduction in effectiveness is greater than the expenditures imply because a significant fraction of RD&D funds are actually being allocated to technical service demands. Furthermore, the technological challenges of the industry are growing at the same time RD&D expenditures are decreasing.

It is clear that the oil and gas industry will need to carefully manage the situation over the next several years in order to assure that it has access to the technology needed for its oil and gas operations.

THE NEW PARADIGM FOR INDUSTRY RD&D

The above-mentioned changes and pressures have led to a "new paradigm" for how the oil and gas industry conducts RD&D. The key characteristics of the new paradigm are leveraging through collaboration, and focus on customer-driven needs.

From a practical management of RD&D point of view, other characteristics are:

- In-house RD&D is focused on the "core technologies" that are critical to business competitiveness and marketplace differentiation.
- Industry is using consortia to minimize the cost of technology for regulatory compliance that provides no competitive advantage.
- The trend in the private sector is largely toward collaboration to develop the fundamental basis required for future technology advances in certain areas.
- RD&D funding is carefully managed to ensure focus on worthwhile targets and timely availability of needed technology.

There are other features and several implications to the new paradigm. *Using* advanced technology effectively and aggressively is considered a *core competency*. Owning the technology is less important except for service companies. However, the oil and gas industry *will* continue to selectively allocate funds to RD&D for proprietary technology.

Advances in oil and gas technologies traditionally enter the marketplace over a long period of time—on the order of a decade. Industry would like to see the cycle time for market introduction reduced through aggressive technology transfer and commercialization efforts. Some producer organizations have dedicated internal staff to accelerate the application of advanced technology within their organization.

All sectors of the oil and gas industry have reduced emphasis on longer term, basic research. However, companies that support RD&D will allocate resources *selectively* to longer term research that is considered vital to their business interests.

Although the private sector will continue to support selected university research, universities are increasingly being asked both to demonstrate that the research has practical application and to obtain higher levels of co-funding from industry or government sources.

Independent producers will continue to be dependent on others for the development, commercialization, and application of advanced technology used in their operations.

WILLINGNESS OF INDUSTRY TO COLLABORATE

Survey Results

The survey sent to NPC members (Appendix D) included a set of questions dealing with the issue of collaboration. The survey provided opportunities to respond either generally (survey questions 14 and 15) or specifically when dealing with specific technology collaboration.

Responses indicated a high overall willingness of industry to collaborate (see Table 4-3). On average, 63 percent of all

TABLE 4-3

WILLINGNESS TO COLLABORATE ON A SPECIFIC TECHNOLOGY
(Percent of Responses)

	Vendors/ Service Com-panies	Oil & Gas Com-panies	Univer-sities	Research Institutes	Trade Assoc.	National* Labs.	DOE†	USGS/ State Survey
All Respondents	*53*	*51*	*48*	*46*	*43*	*42*	*41*	*36*
Majors	66	57	59	56	49	49	44	41
Other Integrated	55	53	43	43	45	35	35	35
Independents	49	48	44	43	43	41	42	35
Service	33	46	39	29	21	34	34	27

*The National Laboratories are Argonne, Brookhaven, Idaho National Engineering Laboratory, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, and Sandia.

†Collaboration with DOE refers to cost-sharing arrangements with Morgantown Energy Technology Center, Pittsburgh Energy Technology Center, National Institute for Petroleum and Energy Research, Metairie Site Office, and Rocky Mountain Oilfield Testing Center.

responses to the question for specific technologies indicated a willingness to collaborate *with one or more of the potential partners listed*. There was a higher interest in collaboration technologies needed in the shorter term (by 1999) than in the longer term (by 2010). However, the willingness varied both by technology area and industry sector.

Responses to the general question—that not tied to a specific technology—indicated that *there is a greater willingness to collaborate than is presently occurring*. This means that more collaboration will likely occur if perceived barriers are addressed. As with the responses tied to specific technologies, these data also indicated a higher willingness to collaborate with organizations that can either be users or providers of technology (i.e., oil and gas companies and vendors/service companies).

The data show a spread from 36 percent to 53 percent in willingness to collaborate when specific technologies were considered. When asked in general, the range jumped to 64–83 percent. This is interesting when one considers that approximately 40 percent of the respondents already collaborate with DOE or the national laboratories.

The survey also provided explanations as to why certain respondents were unwilling to collaborate with particular "partner" categories. In the responses tied to specific technologies, a set of pre-identified barriers could be identified. In rank order, the reasons most frequently selected were:

1. No benefit expected
2. Technology is perceived as too risky
3. Confidential proprietary concerns
4. Intellectual property concerns.

A write-in blank was provided for those who chose the "other reasons" category. Responses included: excessive paperwork and red tape, confidentiality issues, intellectual property issues, limited budgets and resources, and alignment issues such as business objectives, goal orientation, and timelines.

Some of the barriers deserve some exploration and/or clarification. For example:

- *Excessive Paperwork:* The paperwork requirements for working with the federal government are often excessive (even obsessive) and time-consuming for industry personnel. The delays caused by paperwork are exacerbated by lengthy approval chains that DOE and The Labs justify as good business practice.

Some examples of alignment issues that cause problems are:

- *Hold Harmless Agreements:* It is industry practice on collaborative projects to have all organizations execute a Hold Harmless Agreement that makes each organization responsible for the injury or death of only its own employees. However, such agreements are not acceptable to DOE.
- *Uncertainty of Ongoing Funding:* When industry invests in a collaborative project with The Labs, they expect that the project will be carried to completion. However—as is currently being demonstrated—even budget approval does not guarantee continuity of funding.

Finally, even the political environment can cause uncertainties that impede action.

- *Perception of Partnerships:* Recent changes in Congress are prompting a new look at the future role of DOE and the national laboratories, as well as the industry partnership arrangements with DOE and other agencies. The outcome of these decisions could have a profound impact on the magnitude and direction of future interactions between the petroleum industry and The Labs. A common need is providing supporting legislation for stability of funding.

The diversity of the responses written in seems to explain why "other reasons" was ranked high among predefined barriers. It is interesting to note that the ranking of reasons was different for short-term and long-term needs, showing a greater interest on the near term. It can be inferred from this that there is more focus on collaboration for the application of technology in the short term.

In summary, the primary barriers to formation of industry-Lab partnerships are primarily institutional and financial, not technical. To a significant degree, these barriers appear to be the result of redundant layers of management, and the extensive role that DOE maintains even in contractor-operated facilities.

Trends in Willingness to Collaborate

The survey results indicated a willingness to collaborate. The reality of this willingness is demonstrated by several trends:

- The oil and gas industry is establishing industry-funded alliances with other private sector organizations, universities, and the federal government to leverage funds and share in the development of advanced technology. The Petroleum Environmental Research Forum (PERF) is an example.
- Refiners are working closely with individual vendors to specify closely held specialty catalysts and chemicals.
- The oil and gas industry is more receptive to looking at non-industry sources of technology, such as the defense industry and The Labs, for advanced solutions to both traditional and non-traditional problems.
- Strategic alliances among oil companies in the refinery sectors are not common, but their number may be increasing. Most are with foreign entities, although some cooperative development agreements are being made among domestic refineries.

MECHANISMS FOR INDUSTRY-LAB COLLABORATION

As discussed in Chapter Three, there are a number of different and distinct reasons for the oil and gas industry to participate in technology development and transfer with The Labs:

- To address possible shortfalls in industrially sponsored basic research, and perhaps applied research also, including access to unique capabilities.
- To develop and apply technology existing in The Labs.
- To reduce time and cost to develop industry-shared technologies.
- To obtain technology that can enhance efficiency and competitiveness. A large number of industry companies—in particular the independents—don't have in-house RD&D capabilities.

Somewhat corresponding to these different reasons for technology transfer, there are a variety of mechanisms available.[1]

The Partnership Concept

The partnership concept is that the industry and The Labs can team for their mutual benefit. The most appropriate mechanism is determined by the role of the particular technology. The closer the technology is to playing a distinguishing competitive role, the more tightly these collaborations are held. In one extreme, a collaboration will consist of one company and an external research partner in which rights to intellectual property are clearly protected. At the other extreme, a sizable consortia of industry members and vendors will form to pool funding and resources for development of a technology that, by itself, will not impact the relative competitive positions of the companies.

An example of the partnership concept is the Advanced Computational Technology Initiative (ACTI) program, which is focused on strengthening the technology base of the oil and gas industry in exploration, production, and processing. Under ACTI, about $27 million has been allocated to fund 31 projects.

Another is the Natural Gas and Oil Technology Partnership (Partnership), which is an expansion of the Oil Recovery Technology Partnership that was initiated in 1988 by DOE at the Los Alamos and Sandia National Laboratories. This program is focused on transferring to the oil and gas industry technologies derived from DOE-funded weapons and energy, research and development programs.

Cooperative Research and Development Agreements (CRADAs)

The CRADA mechanism was authorized by Congress to facilitate the commercial application of technical capabilities already available in government laboratories. (This mechanism is NOT unique to DOE.) Key features of the CRADA are: (1) industry must cost-share; no transfer of cash is required; the DOE pays its costs, and industry pays its costs; (2) collaborations can be based on existing projects and programs at The Labs; and (3) confidentiality and intellectual property provisions can accommodate the need for project developments to be proprietary.

The cost-share provisions of the CRADA make it more favorable for industry members who already are funding RD&D, and who therefore can use "in-kind" contributions to satisfy the cost-sharing requirement. The CRADA mechanism can be used for a single company-single laboratory partnership, or for one that involves multiple companies and The Labs. A university or other non-profit organization also can be a CRADA participant.

The reviews on CRADAs are mixed. On one hand, as of January 19, 1995, the DOE had initiated 1,157 CRADAs with a total value of over $2 billion. Sixteen percent of these are energy-related (not necessarily oil and gas related). On the other hand, identifying the suitable expert in one of The Labs and agreeing to a statement of work may be the *easiest* part of establishing a CRADA.

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[1] CRADAs and other mechanisms of interaction with The Labs are described in detail in DOE publications including a DOE report entitled "Oil Technology Transfer: A Report to Congress," October 1993, which discusses these programs in some detail.

Other Mechanisms

There is a wide range of other mechanisms by which industry and government laboratories can participate in technical interactions.

Work for Others: Work performed by a laboratory for an industry sponsor that is fully funded by the industry. Results of such work may be proprietary and the sponsor owns rights to developed technology. The laboratories are not allowed, by law, to provide services that are in direct competition with the private sector.

DOE User Facilities: User facilities are unique, complex scientific facilities at The Labs that have been designated by DOE for use by the technical community including private industry. User facilities require only an informal agreement between the industry user and the laboratory, proprietary research is permitted, title to patents is granted to the user, and out-of-pocket cost recovery may be required by the laboratory.

Personnel Exchanges: A temporary transfer of personnel, either from a private industry to a government laboratory or from a government laboratory to a private industry, to exchange expertise and information. Costs are paid by the organization sending the personnel and generally no proprietary data are exchanged. Temporary personnel transfers have proven an extremely effective approach to technology transfer in industry.

Consulting Agreements: An industry party, under a specific written contract, provides advice or information to a laboratory; or a laboratory party, with the approval of the subject laboratory, provides advice or information to a private industry. Intellectual property conflicts must not exist.

Licensing Agreements: The transfer of intellectual property rights to permit industry to use a technology on either an exclusive or non-exclusive basis.

Laboratory Subcontracts with Industry: A formal contract originated by a laboratory to fund a project with private industry as a contractor through a prescribed "Statement of Work" prepared by the laboratory and specific deliverables. The work must be mission-driven and benefit the government. Patent rights belong to the laboratory and data protection and licenses can be negotiated. This can be an important mechanism for The Labs to gain cost-effective access to facilities such as pilot plants for process development (not available within the laboratory system.)

Laboratory Subcontracts with Universities: A formal contract originated by a laboratory to fund a university as a contractor through a prescribed "Statement of Work" and specific deliverables. Results are available to the entire scientific community.

Industry-Lab Visits: The informal and free exchange of information among industry and government laboratory colleagues during visits to one anothers' facilities includes the presentation of technical seminars. If proprietary information is to be disclosed, a Proprietary Information Agreement can be executed.

Technology Transfer Organizations

There are two technology transfer organizations that will assist industry in identifying technologies that might solve particular problems, and sources of that technology within The Labs or in other government facilities.

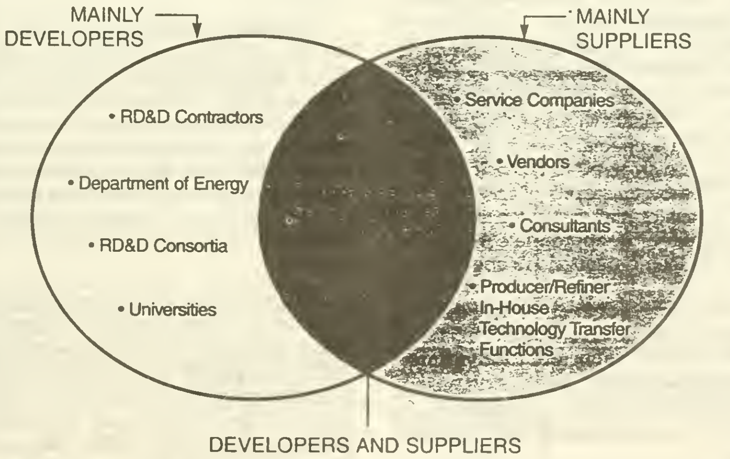
The Petroleum Technology Transfer Council (PTTC) was formed in 1993 by the independent sector of the oil and natural gas industry to improve the dissemination of exploration and production technology and technical information to domestic producers, primarily independents. The PTTC's initial five-year effort is being partially funded by DOE's oil and natural gas programs in the Office of Fossil Energy. Its mission is: (1) to identify priority technical problems of producers and communicate them back to the RD&D community, and (2) to transfer upstream oil and gas technologies that will help domestic producers reduce costs, improve operating efficiency, increase ultimate recovery, enhance environmental compliance, and add new oil and gas reserves. The PTTC serves as an integrated clearinghouse for upstream oil and gas technology information to U.S. petroleum producers.

The National Technology Transfer Center (NTTC) was created to help transfer the research performed in the federal laboratories to U.S. businesses, to put leading edge technologies to work, and create new technologies and jobs. The NTTC's mission is far broader in scope than just the petroleum industry. However, inquiries and responses can relate to virtually any area of technology. Typically about 6 percent relate to energy. NTTC is funded by NASA and other federal agencies.

ALTERNATIVE DEVELOPERS AND SUPPLIERS

Specifically, who are alternative developers and suppliers, what roles might they play under industry's new paradigm for RD&D, and why would they choose to participate?

As illustrated in Figure 4-1, one sector of the industry is mainly concerned with technology development. This sector includes universities, DOE, and RD&D consortia. These organizations recognize that their success is tied directly to the commercial deployment and marketplace impact of technologies they develop. However, they are not in the business of selling the technology (or technology service) for profit. Because their success is so closely tied to the commercialization of the technology



"Suppliers" will be used here to describe organizations that seek earnings by *delivering* a technology-based service to customers in other organizations, or within their own organization.

Figure 4-1. Developers and Suppliers of Technology.

developed, these organizations must pursue a strategy of technology transfer in collaboration with the private sector.

In contrast, there is a sector of the industry that both develops and supplies technology to the oil and gas industry (Figure 4-1). This sector is mainly involved with creating corporate earnings by either delivering a technology-based service to customers or by using the technology in their own business. This sector includes service companies, vendors, and producers/refiners with in-house RD&D programs. Technology development for these organizations provides a basis for increasing earnings and competitive advantage. They have the internal mechanisms and capability to identify, prioritize, and bring to the marketplace the technology they develop.

A third sector of the industry focuses on supplying technology (bringing the technology into practice), but they rely on others to develop the technology. Organizations in this sector include consultants, service companies, and vendors with no RD&D program funding. The financial health of these organizations depends directly on how well they supply appropriate technology to users of the technology. Producers and refiners with no RD&D program funding are a special case in this sector. They are mostly users of technology; however, these organizations often have internal functions or staff that are charged with bringing the most appropriate technology into use in their organization's operations.

Characteristics of Technology Developers and Suppliers: Organizations Exhibit Varied Roles and Motivations

Table 4-4 presents selected characteristics of major technology developers and suppliers for advanced oil and gas technology.

Private Sector

The first three oil and gas industry sectors shown in Table 4-4 have historically invested in development of advanced technology to increase their economic margins and marketplace competitiveness. Producers use technology to reduce the cost of operations. In-house research supported by major producers has been targeted mainly to reduce costs of their *individual* company operations. Their mainline business does *not* include supplying technology broadly to the industry-at-large. In fact, only about a dozen of the major producers, out of the more than 8,000 domestic oil and gas producers, support in-house technology development programs. More than 50 percent of total U.S. oil and gas is produced by organizations with essentially no in-house RD&D programs.

Refiners use technology to reduce the cost of operations or improve the product slate. Although some of the larger refiners have in-house research programs, their mainline business does *not* include providing a technology base to the industry at-large. In this respect, they are similar to producers.

Service companies and vendors earn revenue in the oil and gas industry by supplying advanced technology to users. They have a strong motivation to differentiate themselves from competitors through the effective application of advanced technology, and the marketing of that technology capability to as large a market as they can. Consequently, proprietary ownership of technology advances is important to this sector.

Private sector technology development tends to skew toward the short term, with expectations for products within three years. The survey responses also indicate that private sector in-house RD&D tends to focus on the latter stages of research: product development, product demonstration, and technical service. However, the private sector *will* support selected longer-term, higher-risk programs when the outcomes of those programs are vital to future business interests.

TABLE 4-4

SELECTED CHARACTERISTICS OF DEVELOPERS AND SUPPLIERS

Sector	Major Interest in Technology	Funding Source	Comments
Producers	Improve Economic Margins, Competitive Advantage	Sales Revenue	RD&D Funded Mainly by Majors, RD&D Funds Address Both International and Domestic Resources
Refiners	Improve Economic Margins, Increase Market Share	Sales of Refinery Products	Impacted by Environmental Regulations that Define Fuel Performance
Service Companies/ Vendors	Improve Economic Margins, Increase Market Share	Sales Revenue	Funds Address Both International and Domestic Resources
Federal Government	Energy Security, Competitiveness, Standard of Living	Taxes, Industry Cofunding	
- DOE	Energy Availability; National Security, Economic Stability	Taxes, Industry Cofunding	Increasing Pressure to Secure Industry Cofunding, Current Debate on Role
- MMS	Resource Management	Taxes, Industry Cofunding	Funds Mainly Not Research Oriented
- EPA	Environment	Taxes, Industry Cofunding	Funds Mainly Allocated to Support Setting Regulations
- NIST	Future Social Benefits	Taxes, Industry Cofunding	Focus is Not on Upstream O&G Industry; Crosscutting Research
State Government	Economic Health	Taxes (State & Federal), Industry Cofunding	Limited Budgets, Emphasis on Technology Transfer
- Geologic Survey	Support State Industry	State Funds, Industry Cofunding	New Information on Geological Aspects of O&G Resources
- RD&D Initiatives	Support State Industry	Federal/State Revenue	Some Producing States (e.g., Texas, Oklahoma, New Mexico) Support Limited RD&D Activity
Universities (State and Private)	Education, Support State Industry	State and Private Sector	Resource for Basic Research
Gas Research Institute	Natural Gas Availability and Deliverability; Economic Competitiveness of Natural Gas	Gas Industry Stakeholders: Producers, Pipelines, Distribution Companies and Consumers; Industry Cofunding	Technology Development and Technology Transfer; Mission Emphasizes Technology Transfer
Consultants	Competitive Advantage	Sales Revenue	Mainly Practitioners of Advanced Technology

Public Sector

Federal and state government organizations invest in the development of technology that has implications to oil and gas industry operations. The Department of Energy serves as the major federal organization that supports RD&D directed at the oil and gas industry (see Table 4-4). Federal and state programs must rely on other organizations to deploy the technology they develop.

Several other important federal and state government organizations that develop technology are identified in Table 4-4. In general, these other federal organizations develop technology that addresses many industries, with some elements of their portfolio having implications to oil and gas operations. However, their efforts are not directed at the industry. The RD&D deliverables that *are* applicable are so-called "dual-use" technologies that are complementary to the more general mission that they pursue.

Department of Energy

DOE efforts in advancing technologies are designed to use all domestic energy resources in ways that can promote economic growth while maintaining the nation's commitment to environmental quality. DOE's Office of Fossil Energy has an integral role in this effort by fostering advanced, more efficient, and cleaner oil and gas technologies through a comprehensive research, development, and demonstration program that addresses technological barriers from the reservoir through end use. The programs are coordinated through multiple sites.[2]

The natural gas RD&D program is comprised of the following four areas: Exploration and Production, Delivery and Storage, Gas Processing, and Environment/Regulatory Impact. The gas program complements the natural gas-related activities at other DOE offices such as the Office of Energy Efficiency and Renewable Energy, which is involved in end-use RD&D, and the Office of Energy Research, which is involved in fundamental geoscience and combustion RD&D. The oil RD&D program is comprised of activities that are grouped under the areas of Supporting Research, Field Demonstrations, Environmental Research, and Processing. Supporting Research includes Exploration and Drilling, Extraction, Reservoir Characterization, Technology Transfer, and the Natural Gas and Oil Technology Partnership which coordinates the *Advanced Computational Technology Initiative*.

Table 4-5 shows the FY95 budget for gas and petroleum technologies for DOE's Office of Fossil Energy (in millions of dollars and percentages) as an example of the breakdown of work by performer. This is equivalent to about 1.5 percent of the $7.4 billion of DOE RD&D spending.

State Government

State governments are not major players in the allocation of financial resources to developing advanced technology. An informal telephone survey of major oil and gas producing states suggested that states allocate less than $10 million nationally to independent oil and gas technology programs. The objective of their investment is to provide either educational support or to provide funds that can enhance the economic environment for increased oil and gas business activity in their state. In general, the products of their investment are limited in scope and targeted to issues that fall within their state borders.

Private Sector Consortia

The Gas Research Institute (GRI) supports a significant RD&D program (annual budget of approximately $50 million) di-

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[2] METC - Morgantown Energy Technology Center, Morgantown, West Virginia; PETC - Pittsburgh Energy Technology Center, Pittsburgh, Pennsylvania; BPO/NIPER - Bartlesville Project Office, Bartlesville, Oklahoma, National Institute for Petroleum and Energy Research; MSO - Metairie Site Office, Metairie, Louisiana.

TABLE 4-5

FY 1995 BUDGET FOR GAS AND PETROLEUM TECHNOLOGIES OFFICE OF FOSSIL ENERGY

	Oil	Gas	Total
In-House Research (METC, PETC, NIPER)	$18.3 (22.5%)	$2.1 (7.3%)	$20.4 (18.4%)
National Laboratories (Direct Funding and CRADAs)	$14.2 (17.4%)	$9.5 (33%)	$23.8 (21.5%)
Industry/States/Universities	$49.2 (60.2%)	$17.3 (59.7%)	$66.5 (60%)
Total	$81.7 (100%)	$29.0 (100%)	$110.7 (100%)

rected at *natural gas* exploration, production, processing, and storage operations. GRI is funded by gas industry stakeholders including producers, pipelines, gas distribution companies, and gas consumers. Producers and service companies actively participate in the formulation and evaluation of the GRI program through an extensive network of advisory bodies comprised of technology and policy leaders from the gas industry. Additionally, oil and gas industry organizations participate through cofunding of the development programs.

More than ever, industry considers consortium RD&D organizations as an important component of their business strategy. Industry-sponsored consortia can take a number of forms, including RD&D pools (CEA, DEA, PERF, Deepstar, POSC, university research centers, basic research cooperatives, and industry R&D institutes such as GRI).

- Industry-sponsored consortia are formed to provide members with several benefits, including sharing of costs and risks, improved technology transfer, and leveraging of scarce funds.
  - Because the consortia exist on behalf of their supporters, there is marketplace incentive to be productive. In short, in the new paradigm, consortia are treated as a business unit of the consortium supporters. Relevancy and value-added focus is driven by the participating members.
  - Industry-supported consortia are evaluated on their success in bringing high impact technology to the marketplace. The sponsor's investment in the consortia must show a measurable positive return based on the application of the advanced technology.
- Industry-sponsored consortia do not replace the industry's requirement for development of proprietary technology or technology that addresses the unique needs of a single company.
  - In general, technology developed by the consortia is shared by the funding members.
  - Individual company goals are relinquished in consortium RD&D in lieu of consensus goals.

SUMMARY

As discussed in this chapter, the nature of the technology programs supported by the different organizations varies considerably, in both focus and time horizon. In general, those organizations competing in the private sector limit their time horizon to the very near term (immediate to three years), and accordingly emphasize technical service and product development. In contrast, universities conduct very basic research that is targeted to provide the technology base for future products. Characteristic time horizons tend toward ten years or more. Federal and state funded technology development lies somewhere between these two end-points, with elements of their programs targeted toward basic research, technology development, and technology transfer. In general, programs supported by the federal or state governments will tend to emphasize the longer term, whereas partnerships and consortia supported by private funds will tend toward the shorter term.

APPENDICES

APPENDIX A

REQUEST LETTER AND DESCRIPTION OF THE NATIONAL PETROLEUM COUNCIL

The Secretary of Energy
Washington, DC 20585

July 27, 1994

Mr. Ray L. Hunt
Chairman
National Petroleum Council
1625 K Street, N.W.
Washington, DC 20006

Dear Mr. Hunt:

The Department of Energy (DOE) has recently forwarded to Congress and industry a draft program plan for the Advanced Computational Technology Initiative. This program is a key component of the Administration's Domestic Natural Gas and Oil Initiative, released last December, and is part of the existing Natural Gas and Oil Technology Partnership (Partnership) operated by the National Laboratories and the Department.

The Partnership is an expansion of the successful Oil Recovery Technology Partnership, a Department funded program initiated by the Los Alamos and Sandia National Laboratories in 1988. Two additional labs have since been incorporated in fiscal year 1994, and the Partnership will include the remaining five multi-program laboratories in fiscal year 1995.

The mission of the Partnership is to stimulate, facilitate, and coordinate the development and transfer of technology to the U.S. petroleum industry through technical interactions and collaborations with DOE's National Laboratories. The Partnership has four areas of focus or technology areas. The Advanced Computational Technology Initiative addresses one such technology area. Each focus area has an industry interface group, called a panel or forum, which is key to providing the industry-driven aspect of the Partnership.

The Advanced Computational Technology Initiative program is designed to enhance, apply, and transfer technologies developed within our National Laboratories to promote the competitiveness of domestic natural gas and oil companies. Specifically, the program will redirect the National Laboratories' computational capabilities to support the natural gas and oil industry and to accelerate the next revolution in exploration, production, and processing technologies. The underlying goals of the Advanced Computational Technology Initiative are to help producers find and recover natural gas and oil at lower costs and to enhance and apply technologies to increase domestic production.

To ensure the success of the Advanced Computational Technology Initiative and other technology programs in the Partnership, I am requesting that the National Petroleum Council (Council) conduct a study of research, development, and demonstration needs of the natural gas and oil industry. This study should analyze the needs of all components of the industry, considering the near- and long-term needs of both the upstream and downstream sectors. Significantly, your study will serve as the foundation for the Partnership's Industry Steering Committee, which provides program direction, and helps set funding allocations and other priorities.

This is an important study that, in my view, deserves expedient but thorough attention. As the initial funding for Advanced Computational Technology Initiative projects become available in fiscal year 1995 (beginning October 1, 1994), I would ask that the Council establish a schedule that would provide an interim report on the research, development, and demonstration needs study before the end of the year, with the final report as soon thereafter as possible.

Thank you for your continued assistance on issues important to the energy industry.

Sincerely,

Hazel R O'Leary

Hazel R. O'Leary

DESCRIPTION OF THE NATIONAL PETROLEUM COUNCIL

In May 1946, the President stated in a letter to the Secretary of the Interior that he had been impressed by the contribution made through government/industry cooperation to the success of the World War II petroleum program. He felt that it would be beneficial if this close relationship were to be continued and suggested that the Secretary of the Interior establish an industry organization to advise the Secretary on oil and natural gas matters.

Pursuant to this request, Interior Secretary J. A. Krug established the National Petroleum Council on June 18, 1946. In October 1977, the Department of Energy was established and the Council was transferred to the new department.

The purpose of the NPC is solely to advise, inform, and make recommendations to the Secretary of Energy on any matter, requested by the Secretary, relating to oil and natural gas or the oil and gas industries. Matters that the Secretary of Energy would like to have considered by the Council are submitted in the form of a letter outlining the nature and scope of the study. This request is then referred to the NPC Agenda Committee, which makes a recommendation to the Council. The Council reserves the right to decide whether it will consider any matter referred to it.

Examples of recent major studies undertaken by the NPC at the request of the Secretary of Energy include:

- *U.S. Arctic Oil & Gas* (1981)
- *Environmental Conservation—The Oil & Gas Industries* (1982)
- *Third World Petroleum Development: A Statement of Principles* (1982)
- *Enhanced Oil Recovery* (1984)
- *The Strategic Petroleum Reserve* (1984)
- *U.S. Petroleum Refining* (1986)
- *Factors Affecting U.S. Oil & Gas Outlook* (1987)
- *Integrating R&D Efforts* (1988)
- *Petroleum Storage & Transportation* (1989)
- *Industry Assistance to Government* (1991)
- *Short-Term Petroleum Outlook* (1991)
- *The Potential for Natural Gas in the United States* (1992)
- *U.S. Petroleum Refining—Meeting Requirements for Cleaner Fuels and Refineries* (1993)
- *The Oil Pollution Act of 1990—Issues and Solutions* (1994)
- *Marginal Wells* (1994)
- *Future Issues—A View of U.S. Oil & Natural Gas to 2020* (1995).

The NPC does not concern itself with trade practices, nor does it engage in any of the usual trade association activities. The Council is subject to the provisions of the Federal Advisory Committee Act of 1972.

Members of the National Petroleum Council are appointed by the Secretary of Energy and represent all segments of the oil and gas industries and related interests. The NPC is headed by a Chair and a Vice Chair, who are elected by the Council. The Council is supported entirely by voluntary contributions from its members.

NATIONAL PETROLEUM COUNCIL

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APPENDIX B

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APPENDIX C

STATISTICAL DATA ON THE OIL AND GAS INDUSTRY

U.S. Energy Consumption Summary: 1970-1993

	1970	1975	1980	1985	1990	1993
U.S. Energy Consumption (Quads)	66.43	70.55	75.96	73.98	81.26	83.96
Petroleum	29.52	32.73	34.2	30.92	33.55	33.77
Natural Gas	21.79	19.95	20.39	17.83	19.3	20.79

Source: EIA Annual Energy Review, 1993, page 5.

1993 U.S. Energy Consumption by End-Use Sector

Quadrillion BTUs

	Total	Percent
Industrial	30.77	36.7
Residential and Commercial	30.34	36.1
Transportation	22.83	27.2
Total	83.96	100.0

Source: EIA Annual Energy Review, 1993, page 39.

1992 Consumption of Liquid Transportation Fuels

	Total	Cars	Buses	Trucks
Fuel Consumption (Billion Gallons)		73.9	0.9	58.0
Fuel Consumption (Quadrillion BTUs)*	22.83	9.24	0.12	8.04
Total	76.2	40.5	0.5	35.2

* Fuel consumption (gallons) data for cars was converted to BTUs using the heat content for gasoline: 5.253 million BTUs per barrel. Data for buses and trucks were converted using the heat content of distillate-fuel oil, 5.825 million BTUs per barrel. Source: EIA Annual Energy Review, 1993, page 341.

Source for fuel consumption data: Statistical Abstract of the United States, 1994, Table No. 1024.

1993 Electric Utility Consumption of Fossil Fuels to Generate Electricity

	Total	Oil	Gas	Coal
Consumption to Generate Electricity (Quads)	20.71	1.05	2.74	16.92
Total Consumption (Quads)	83.96	33.77	20.79	19.63
% of Total Consumption of Energy Source	24.67	3.10	13.18	86.19

Source: EIA Annual Energy Review, 1993, page 237.

U.S. Per Capita Energy Consumption: 1970-1993

	1970	1975	1980	1985	1990	1993
Per Capita Energy Consumption (million BTU)	327	351	327	311	326	326

Source: Statistical Abstract of the United States, 1994, Table No. 922.

Energy Consumption: 1970-1993

	1970	1975	1980	1985	1990	1993
Energy Consumption (thousand BTU) per $GDP	23.1	21.9	20.1	17.3	16.6	16.3

Source: Statistical Abstract of the United States, 1994, Table No. 922.

Motor Fuel Consumption and Motor Vehicle Efficiency

	Total Motor Fuel Consumption (Billion Gallons)	Average miles per gallon	
		Cars	Trucks
1970	92.3	13.52	7.85
1992	132.9	21.60	10.84
Percent change	+44.0	+59.8	+38.0

Source: Statistical Abstract of the United States, 1994, Table No. 1020.

1993 U.S. Domestic Energy Production

Quads

	Total	Oil	Gas	Coal	Nuclear	Hydro-electric	Other
Consumption	83.96	33.77	20.79	19.63	6.52	3.06	0.20 (a)
Domestic Production	65.81	16.88	18.98	20.49	6.52	2.76	0.18 (b)
Percent of Domestic Production	78.4	50.0	91.3	100	100	90.2	90.0

(a) Natural gas, petroleum products, electricity and coal coke.

(b) Electricity generated for distribution from wood, waste, geothermal, wind, photovoltaics, and solar thermal energy. Natural gas liquids included with oil.

Source: EIA Annual Energy Review, 1993, page 5.

U.S. Oil and Gas Reserves, January 1, 1993

Recoverable with current technology and prices

	Crude Oil (Billion Barrels)	Natural Gas (Trillion Cubic Feet)
Reserves	23.7	165.0
Current Rates of Production	2.5	18.4
Years Supply at Current Rates of Production	9.5	9.0

Sources: Reserves and current production data from EIA Annual Energy Review, 1993, pages 129, 141, 189, and 287. Reserves do not include natural gas liquids.

Oil and Gas Prices—Summary: 1970-1993

1987 Dollars

	1970	1975	1980	1985	1990	1993
Crude Oil Domestic First Purchase Price—U.S. Average ($/bbl)	9.03	15.59	30.11	25.52	17.68	11.47
Leaded Reg. Gasoline—Retail ($/gal)	1.014	1.152	1.662	1.181	1.014	—
Unleaded Reg. Gasoline—Retail ($/gal)	—	—	1.736	1.273	1.027	.892
Fuel Oil—Retail ($/gal)	0.526	0.766	1.358	1.115	0.938	0.733
Natural Gas—Wellhead ($/MCF)	0.48	0.89	2.22	2.66	1.51	1.59

Source: EIA Annual Energy Review, 1993, pp. 173, 183, 203.

Consumer Price Indexes for All Urban Consumers (CPI-U): 1980-1993

100 = 1982-1984 averages.

Item	1980	1985	1990	1993	Percent Change
All Items	**82.4**	107.6	130.7	**144.5**	75
Food and Beverages	86.7	105.6	132.1	141.6	63
Housing	81.1	107.7	128.5	141.2	74
Fuels and Other Utilities	75.4	106.5	111.6	121.3	61
Fuel Oil	**87.7**	**94.6**	**98.6**	**87.2**	(1)
Electricity	75.8	108.9	117.4	126.7	67
Utility (piped) gas	65.7	104.8	97.3	106.5	62
Household Furnishing and Operations	86.3	103.8	113,3	119.3	38
Apparel and Upkeep	90.9	105.0	124.1	133.7	47
Transportation	83.1	106.4	120.5	130.4	60
New Vehicles	88.4	106.1	121.0	131.5	49
Motor Fuel	**97.4**	**98.7**	**101.2**	**98.0**	**1**
Automobile Maintenance	81.5	106.8	130.1	145.9	79
Automobile Insurance	82.0	119.2	177.9	216.7	164
Medical Care	74.9	113.5	162.8	201.4	169
Entertainment	83.6	107.9	132.4	145.8	74
Tobacco and Smoking Products	72.0	116.7	181.5	228.4	217
Personal Care	81.9	108.3	130.4	141.5	73
Personal and Educational Expenses	70.9	119.1	170.2	210.7	197

Source: Statistical Abstract of the United States, 1994, Table No. 748.

Q2. On page 16 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "EIA projects a one-third increase in domestic natural gas consumption by 2015, about half for electric power production. This will require increasing amounts of gas to be drawn from parts of the vast domestic resource base that are not economical to recover due to geological setting, quality of the gas, or location relative to infrastructure."

However, Tables A13 and A14, on pages 106 through 109 of EIA's *Annual Energy Outlook 1996*, show that, for EIA's reference case, gas supply through 2015 is no problem even at the modest annual growth rates in gas prices (1.5% for wellhead prices and 0.3% for delivered prices). In light of this, please explain the statement that increased domestic natural gas consumption "will require increasing amounts of gas to be drawn from parts of the vast domestic resource base that are not economical to recover due to geological setting, quality of the gas, or location relative to infrastructure."

A2. The relative ease with which EIA's *Annual Energy Outlook 1996* shows gas supply meeting demand through the year 2015 masks two important factors. First, these forecasts assume a steady significant rate of gas recovery technology improvement. Second, gas demand in the EIA forecasts is strong through the 2015 forecast period and assumes continuous expansion of the infrastructure, including the construction of many combined cycle electric generation plants. The transportation, storage and infrastructure will be in service for several decades, and thus the issue is not simply meeting a large 2015 demand, but also the ability to continue to supply affordable gas through at least the middle of the next century.

Underlying EIA supply/price forecasts are technology improvement assumptions of 3% per year for undiscovered deep onshore gas, all undiscovered offshore gas, and tight gas, Devonian Shale, and coalbed methane. It also assumes a 2% per year improvement for undiscovered shallow onshore gas. The purpose of the Department's program is to work with industry to help sustain levels of technological progress needed to meet our future natural gas needs. Unfortunately, domestic RD&D has been declining, including recent significant reductions at the Gas Research Institute.

The EIA forecast assumes that the R&D investment must focus on unconventional gas recovery since that is the single largest source of natural gas, as confirmed by the USGS' 1995 Oil & Gas Resource Assessment. This is the focus of the DOE Natural Gas Exploration & Production Program. Most proved reserves are made up of the "easy" to find and produce natural gas, and that the next largest target is the tight gas, the Devonian Shale, and the coalbed methane resources. Successful exploitation of resources such as these face a variety of impediments:

- These geologic formations are generally deeper, and more geologically-complex.

- The quality of the natural gas, that is, its BTU content, varies from reservoir to reservoir. Parts of the unconventional resource, and up to 1/3 of the almost 1300 TCF of undiscovered natural gas assessed by the USGS and the MMS is of low BTU content and must be treated or "upgraded" before use.

- Elaborate infrastructure will be needed to move the gas from the site where it is produced to the location where it is used. This is especially important for many of the remote, unconventional fields, and it will be important to find ways to lower the costs of infrastructure or reduce the need (e.g., more efficient storage).

Q3. On page 18 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "A billion dollar project would result in approximately 15,000 new U.S. jobs per year."

Please provide detailed documentation, including assumptions, that supports this claim.

A3. The figure of 15,000 new U.S. jobs per year for every billion dollars of U.S. exports is similar to estimates used by several agencies, including the Export-Import Bank, the Trade Promotion Coordinating Committee in the Department of Commerce, and the Overseas Private Investment Corporation (OPIC). OPIC, for example, includes the indirect effects as well as the direct effects in its estimates of the impact of foreign investment on U.S. industry. In general, OPIC calculates the dollars of output per worker. Using 1993 data for all manufacturing, the direct effect was $152,088 per worker and the indirect effect was $101,265. This translates into a direct multiplier of 6,575 workers employed per billion dollars of exports for one year and an indirect multiplier of 9,875 workers employed per billion dollars of exports for one year. The total multiplier is thus 16,450 jobs per billion dollars of exports. This is the basis for the "approximately 15,000" jobs figure cited in the budget request.

COAL: ADVANCED CLEAN FUELS RESEARCH

Q4. On page 30 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "The FY 1997 budget request supports the continued development of coal liquefaction technologies at the laboratory and bench scale in support of the objective of providing substitute liquid fuels at costs competitive with crude oil around $19-$25 per barrel within the next decade."

Q4a. Please provide a status report on the current state of liquefaction technology development.

A4a. Studies for "stand-alone" coal liquefaction technology have shown that these technologies, which have been studied at the bench and proof-of-concept scale, presently offer the potential to economically compete with crude in the $32-$34 per barrel range. The engineering estimates we have obtained concluded that with continued research and development, advanced stand-alone coal-derived fuel technologies might compete with crude at $27 per barrel. In addition, engineering estimates based on limited laboratory and exploratory continuous bench scale operation has identified the potential for entrance technologies such as (1) for direct liquefaction - coprocessing of coal/waste and coal/resid; and (2) for indirect liquefaction - coproduction of electricity, hydrocarbon fuels, and chemicals utilizing a variety of feedstocks (coal, natural gas, petroleum coke and refinery wastes). These entrance technologies, which would utilize existing refinery or gasification facilities to reduce capital and hydrogen requirements, offer the potential for further reductions in liquid fuel costs to the $19-$25 per barrel range.

Direct Liquefaction technology was significantly improved with the development of close-coupled, two-staged technology in the late 1980's and early 1990's. In the two-stage concept, the coal dissolution and hydrocracking and hydrotreating are conducted in separate stages producing more distillate with lower-hydrogen usage. Continued research can provide further improvements in productivity and quality by the development of improved catalysts and simpler reactor systems. Indirect liquefaction technology has been significantly improved by the development of slurry-phase reactor systems that is being demonstrated for the production of methanol in the Clean Coal Demonstration Program. Through continued development, this improved reactor technology could be applied for producing premium hydrocarbon transportation fuels and oxygenated chemicals from synthesis gas with lower cost.

Q4b. Please provide detailed documentation, including assumptions, that demonstrate that "the objective of providing substitute liquid fuels at costs competitive with crude oil around $19-$25 per barrel within the next decade" is reasonable.

A4b. An engineering analysis based on exploratory bench scale runs concluded that coprocessing of coal/resid or coal/waste in a facility adjacent or integrated into an existing refinery offers the potential to produce liquid fuels competitive with crude at $19 to $23 per barrel. The assumptions are shown in the attached table (Gray and Tomlinson, (9th Annual CFFLS Technical Meeting, Pipestem, WV, August 1995).

The distillate products from the coprocessing facility can be blended and upgraded in the refinery.

An analysis has also described the potential for coproduction of electricity, liquid fuels, and chemicals by gasification of coal and/or petroleum coke at existing refineries. This technology has the potential for production of liquid fuels which could compete with crude at $25 per barrel (reference: Gray and Tomlinson, A Technical and Economic Comparison of Natural Gas and Coal Feedstocks for Fischer-Tropsch Synthesis, 4th International Natural Gas Conversion Symposium, November 1995). The key financial parameters used in the price calculations are: 25% owner equity, 8% interest rate on loans, 3% inflation, plant life 25 years, 15% DCF return. If research activities are successfully conducted, these technologies could be developed in the 2000-2010 time frame.

Table of Assumptions: Coal/Waste Economic Analysis

- Single train of two-staged liquefaction
- Integrated with refinery
- Feedstock costs:
    - Illinois coal: $25/ton dry
    - Black Thunder coal: $10/ton dry
    - Plastics: $0/ton
- Feedstock Preparation Cost
    - Plastics: $20/ton
- Refinery Services
    - Gas cleanup
    - By-product recovery

Coal Preparation

Q5. Please provide a listing of the recipients of (i) the $7,040,000 in funding in FY 1995, (ii) the $4,666,000 in FY 1996 funding, and (iii) the requested level of $5,099,000 in FY 1997 for Coal Preparation, including the funding for each recipient.

A5.

Coal Preparation Funding Recipients
(Expressed in $ thousands)

ORGANIZATION	**FY95**	**FY96**	**FY97**
Cypress Emerald	5	0	0
University of Kentucky	28	0	0
Control International	266	0	200
Alberta Research Council	300	0	200
Virginia Polytechnic Institute	400	0	200
(High Efficiency)			
AMAX	1,608	1,600	1,125
CQ Inc.	262	150	215
U.S. Geological Survey	38	57	0
Virginia Polytechnic Institute	300	35	147
(Hazardous Air Pollutants)			
Little Bear Laboratory	300	26	227
Idaho National Engineering Lab	0	68	60
PETC In-House	2,650	2,650	2,250
Hazardous Air Pollutant Downselection	0	0	179
Advanced Dewatering (TBD)	0	0	190
Burns & Roe Program Support	0	33	55
HQ Support	72	47	51
Alt Fuels (In-House)	811	0	0
Total	**7,040**	**4,666**	**5,099**

Q6. For each recipient of Coal Preparation funds identified in the response to question 5 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A6.

Coal Preparation Funding Recipient Cost-Sharing
(Percent Cost Share)

ORGANIZATION	FY95	FY96	FY97
Cypress Emerald	32.8	-	-
University of Kentucky	27	-	-
Control International	32.5	32.5	32.5
Alberta Research Council	25	25	25
Virginia Polytechnic Institute	27	27	27
(High Efficiency)			
AMAX	11.3	11.3	11.3
CQ Inc.	24.1	24.1	24.1
U.S. Geological Survey	-	-	-
Virginia Polytechnic Institute	21.2	21.2	21.2
(Hazardous Air Pollutants)			
Little Bear Laboratory	20	20	20
Idaho National Engineering Lab	-	-	-
PETC In-House	-	-	-
Hazardous Air Pollutant Downselection	-	-	20% Min
Advanced Dewatering (TBD)	-	-	20% Min
Burns & Roe Program Support	-	-	-
HQ Support	-	-	-
Alt Fuels (In-House)	-	-	-

Q7. For those Coal Preparation funding recipients listed in the response to question 5 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A7. None of the organizations listed in question 5 received funds on a non-competitive basis.

Q8. On page 31 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1997, it is stated: "Provide customer service including business planning ($10)."

Q8a. Which specific "customers" are going to be provided "service"?

A8a. The customers mentioned in the key activity are those users of industrial coal preparation technology such as that which has been developed under the Coal Preparation Program.

Q8b. Who specifically is going to "provide" this "customer service"?

A8b. The service, which would consist of facilitating the commercialization of Coal Preparation systems developed under the Coal Preparation Program, would be provided by the DOE Headquarters Program Manager with the assistance of the Headquarters support contractor which at this time is Gilbert Commonwealth, Inc.

Q9. Please describe the "high efficiency process development efforts at outside facilities" (page 31 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995- FY 1997).

A9. The "high efficiency process development efforts at outside facilities" referred to on page 31 of Volume 4 of the *FY 1997 Congressional Budget Request*, are listed below:

Cypress Emerald is developing an advanced flotation unit to clean 100 mesh x 0 coal fines. Cypress Emerald will conduct laboratory and bench-scale evaluations of various flotation units including a Jameson cell, open, and packed columns. The best technology will be scaled to a three-ton-per-hour proof-of-concept unit that will be incorporated into a 100- to 600-gallon-per-minute slipstream at Cypress Emerald's preparation plant in Waynesburg, Pa. A technical evaluation and economic model will be prepared to estimate the size and number of units required to process 75 tons per hour of fine coal.

University of Kentucky is evaluating a novel surface modification technique using metal ions and surfactants to dewater ultrafine clean coal at a scale of one to two tons per hour. The surface modification technique is being tested with vacuum, centrifuge and hyperbaric filtration systems.

Control International is testing an advanced control system for fine coal flotation using an optical sensor for on-line ash analysis. Classical methods of control have some severe limitations due to the non-linear nature of the flotation process. The first phase involves laboratory tests, plant testing, and computer simulations, the second phase will test the system at the Maple Meadow coal preparation plant.

Alberta Research Council is developing and demonstrating, at proof-of-concept scale, oil agglomeration equipment to improve the recovery and quality of fine coal from conventional coal cleaning circuits. Two distinct systems will be evaluated, a conventional high-shear mixer and a novel tubular processor.

Virginia Polytechnic Institute is investigating triboelectrostatic separation for fine dry coal. The project goal is to define, at POC scale, the performance of the process in terms of equipment costs, energy recovery, ash and sulfur rejection, and throughput capacity. Most coal cleaning processes are wet processes. This process, originally developed at PETC, is a dry process and offers improved environmental performance and fewer ancillary problems by avoiding the dewatering required by most other coal cleaning processes.

Q10. Please describe the "technical and program management support" (page 32 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A10. The technical and program management support activity in the Coal Preparation Program provides system studies and analyses and market assessments which assist in the strategic planning, prioritization, and decision making process for the program. In addition, the technical and management support activities provides logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the Coal Preparation Program's strategic planning.

Direct Liquefaction

Q11. Please provide a listing of the recipients of (i) the $8,617,000 in funding in FY 1995, (ii) the $5,580,000 in FY 1996 funding, and (iii) the requested level of $5,857,000 in FY 1997 for Direct Liquefaction, including the funding for each recipient.

A11.

Direct Liquefaction Funding Recipients
(in Thousands $)

CONTRACTOR	TITLE	FY95	FY96	FY97
UK-CAER	Advanced Liquefaction	1,207	1,500	1,016
Exxon	Slurry Catalyst Testing	60	0	0
HTI	Bench-Scale Co-Processing	400	400	400
Burns & Roe	Technical Support	78	100	200
PETC	PETC In-House	1,085	1,000	1,200
SNL	Tech Base	750	400	727
UNDEERC	Low-Rank Coal	0	200	0
WVU	Non-Fuel Use of Coal	301	0	0
CONSOL	Improved Liq. (Formate)	600	300	700
Clark Atlanta Univ.	Surface Modified Coals	100	0	0
Univ. of Kentucky	Plastics Co-Processing	147	0	0
HTI	POC Facility	2,175	0	0
CONSOL	Process Streams Characterization	350	200	200
Mitretek	Res. Guidance/Eng. Studies	191	288	300
Bechtel	End-Use Studies	575	400	500
TBD	Waste/Coal Co-liquefaction	0	736	555
HQ	Tech. & Man. Support	98	56	59
HQ	SBIR	180	0	0
Total		**8,297***	**5,580**	**5,857**

*$8,297,000, rather than $8,617,000, was obligated for the Direct Liquefaction in FY 1995.

Q12. For each recipient of Direct Liquefaction funds identified in the response to question 11 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A12.

Direct Liquefaction Funding Recipient Cost-Sharing (in Thousands $)

CONTRACTOR	TITLE	FY95	FY96	FY97
UK-CAER	Advanced Liquefaction	0	0	0
Exxon	Slurry Catalyst Testing	0	0	0
HTI	Bench-Scale Co-Processing	56	56	56
Burns & Roe	Technical Support	0	0	0
PETC	PETC In-House	0	0	0
SNL	Tech Base	0	0	0
UNDEERC	Low-Rank Coal	0	0	0
WVU	Non-Fuel Use of Coal	75	0	0
CONSOL	Improved Liq. (Formate)	96	48	112
Clark Atlanta Univ.	Surface Modified Coals	0	0	0
Univ. of Kentucky	Plastics Co-Processing	0	0	0
HTI	POC Facility	435	0	0
CONSOL	Process Streams Characterization	0	0	0
Mitretek	Res. Guidance/Eng. Studies	0	0	0
Bechtel	End-Use Studies	0	0	0
TBD	Waste/Coal Co-liquefaction	0	0	0
HQ	Tech. & Man. Support	0	0	0
HQ	SBIR	0	0	0
Total		662	104	168

Q13. For those Direct Liquefaction funding recipients listed in the response to question 11 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A13. EXXON–Recipient furnished the only continuously operating unit of its kind in the country for investigating DOE-specified slurry catalysts in plug flow reactors.

UNDEERC–Recipient had submitted an excellent unsolicited proposal (USP) for addressing a key problem area in the direct liquefaction of low-rank coals.

WVU–West Virginia University (WVU) Research Corporation and the Carbon Products Consortium (CPC) proposed developing a unique and innovative coal extraction process for establishing a coal-based supply of raw materials. These materials are useful in preparing a variety of carbon products including electrode binder and impregnation pitches, green cokes, graphites, carbon fibers, and carbon-carbon composites.

CONSOL–Recipient submitted an excellent USP to conduct research in a novel area of first-stage reaction chemistry.

U of Kentucky–Recipient proposed a unique site-specific economic study for scale-up of its own research data on waste coprocessing.

HTI–HTI's Proof-of-Concept (POC) facility is the only operating unit of its kind in the country for testing innovative ideas in direct coal liquefaction at the 3-ton-per-day scale.

Mitretek–Recipient has an extensive background and detailed information base on the scale-up and economic evaluation of coal liquefaction processes. Recipient utilizes an in-house computer program to rationalize and predict the economic impact of key experimental results for guidance of DOE's experimental program in direct liquefaction.

SNL–Sandia National Laboratories proposed its unique, specialized talents, institutional expertise, and laboratory facilities for supporting and furthering the technology base that is the foundation for the Direct Liquefaction Program.

PETC–The PETC bench-scale facilities are intermediate in scale between the laboratory-scale facilities possessed by most liquefaction program contractors and larger bench-scale units at HTI. The lower-cost process variable and catalyst screening capabilities at PETC are needed to evaluate promising new ideas and concepts before committing to the more highly integrated (and more expensive) facilities at HTI. PETC in-house also has unique analytical capabilities for coal conversion product and process characterization that augment those elsewhere in the program.

Q14. Please describe the "supporting engineering and economic guidance at Mitretek" (pages 32 and 33 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1996 and FY 1997).

A14. Mitretek, using its extensive liquefaction technology background and modeling capability, has developed a computer model to perform scoping economics studies for coal liquefaction technology. The model has proved effective as a tool to provide answers to the "if and what" scenarios for coal liquefaction R&D and, therefore, is very helpful in defining improvements. The research guidance from these studies has been essential for DOE to implement its Coal Liquefaction Program in a cost-efficient manner. The good rapport and respect which Mitretek has established with DOE contractors and other interested organizations doing research in coal liquefaction is an important ingredient for the success of their work.

Q15. Please describe the "end use and emissions study for coal derived transportation fuels" (page 33 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A15. The objective of the "coal liquids end use and emissions study" is to develop a data base for coal liquids to be used as part of the crude mix in a conventional refinery. The scope of work includes the co-refining of crude and coal liquids, engine emission tests of co-refined products, and modification of a generic refinery operation model to incorporate the use of coal liquids. The final deliverable will be a data package which defines the preferred options for upgrading coal liquids in the refinery to optimize the their value. The coal liquids used in this study were produced from the proof-of-concept (POC) units at HTI (New Jersey). The prime contractor is Bechtel and subcontractors are Southwest Research Institute, Kellogg, and Amoco.

Q16. Please describe the "technical and program management support" (page 33 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A16. The technical and program management support activity assists the Direct Liquefaction Program by providing coal technology systems studies, analyses, and market assessments to assist in the strategic planning, prioritization, and decision-making process for the Coal Technology Program. The support activity also provides program information and technology assessments of international competitors to assess their progress, degree of emphasis, and program direction. In addition, the technical and management support activities provide logistical and facilitates assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback to coal technology strategy and planning.

Indirect Liquefaction

Q17. Please provide a listing of the recipients of (i) the $12,202,000 in funding in FY 1995, (ii) the $5,836,000 in FY 1996 funding, and (iii) the requested level of $4,252,000 in FY 1997 for Indirect Liquefaction, including the funding for each recipient.

A17.

Indirect Liquefaction Funding Recipients

Recipients	FY 1995	FY 1996	FY 1997
PETC (PETC in-house)	$696,000	$600,000	$405,000
Burns and Roe (Technical support)	$102,000	$180,000	$101,000
Sandia National Lab	$500,000	$500,000	$500,000
Brookhaven National Lab	$100,000	$0	$0
University of Kentucky	$0	$62,000	$0
Texas A&M	$0	$172,000	$0
Kentucky Center for Applied Energy Research	$754,000	$543,000	$428,000
Air Products and Chemicals (Reactor Design)	$285,000	$243,000	$314,000
Washington University (Reactor Design)	$358,000	$362,000	$317,000
Ohio State University (Reactor Design)	$133,000	$140,000	$147,000
University of Trondheim	$21,000	$21,000	$21,000
Air Products and Chemicals (Alt. Fuels)	$4,798,000	$1,343,000	$1,601,000
Bechtel (Alt. Fuels)	$871,000	$295,000	$0
Eastman Chemicals (Alt. Fuels)	$895,000	$0	$0
Leigh University (Alt. Fuels)	$269,000	$0	$0
University of Delaware (Alt. Fuels)	$90,000	$0	$0
University of Aachen (Alt. Fuels)	$110,000	$0	$0
Amoco	$150,000	$147,000	$0
Research Triangle Institute (Chemicals)	$234,000	$40,000	$0
Bechtel (Chemicals)	$49,000	$8,000	$0
Eastman Chemicals (Chemicals)	$167,000	$29,000	$0
University of California	$213,000	$231,000	$0
Air Products and Chemicals	$37,000	$40,000	$0
Bechtel (systems integration)	$376,000	$100,000	$0
Bechtel (refining/end use)	$190,000	$425,000	$0
Mitretek	$191,000	$191,000	$170,000
Morgantown Energy Technology Center	$395,000	$0	$0
Syngas Production/Cleanup TBD	$0	$0	$128,000
Headquarters	$0	$58,000	$43,000
SBIR	$0	$106,000	$77,000
HBCU	$100,000	$0	$0
Congressional Rescission	$150,000	$0	$0
Less FY 1994 Carryover Funding	($32,000)	$0	$0
Total	**$12,202,000**	**$5,836,000**	**$4,252,000**

Q18. For each recipient of Indirect Liquefaction funds identified in the response to question 17 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A18.

Indirect Liquefaction Funding Recipient Cost-Sharing

Recipients	FY 1995	FY 1996	FY 1997
PETC (PETC in-house)	$0	$0	$0
Burns and Roe (Technical support)	$0	$0	$0
Sandia National Lab	$0	$0	$0
Brookhaven National Lab	$0	$0	$0
University of Kentucky	$0	$0	$0
Texas A&M	$0	$11,000	$0
Kentucky Center for Applied Energy Research	$388,000	$280,000	$220,000
Air Products and Chemicals (Reactor Design)	$199,000	$192,000	$200,000
Washington University (Reactor Design)	$0	$0	$0
Ohio State University (Reactor Design)	$0	$0	$0
University of Trondheim	$0	$0	$0
Air Products and Chemicals (Alt. Fuels)	$947,000	$347,000	$320,000
Bechtel (Alt. Fuels)	$236,000	$63,000	$0
Eastman Chemicals (Alt. Fuels)	$224,000	$0	$0
Leigh University (Alt. Fuels)	$0	$0	$0
University of Delaware (Alt. Fuels)	$0	$0	$0
University of Aachen (Alt. Fuels)	$0	$0	$0
Amoco	$38,000	$37,000	$0
Research Triangle Institute (Chemicals)	$0	$0	$0
Bechtel (Chemicals)	$0	$0	$0
Eastman Chemicals (Chemicals)	$167,000	$29,000	$0
University of California	$54,000	$58,000	$0
Air Products and Chemicals	$9,000	$10,000	$0
Bechtel (systems integration)	$0	$0	$0
Bechtel (refining/end use)	$0	$0	$0
Mitretek	$0	$0	$0
Morgantown Energy Technology Center	$0	$0	$0
Syngas Production/Cleanup TBD	$0	$0	$0
Total	**$2,262,000**	**$1,027,000**	**$740,000**

Q19. For those Indirect Liquefaction funding recipients listed in the response to question 17 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A19. Five indirect liquefaction funding recipients were awarded on a non-competitive basis:

Contractor 1: Air Products and Chemicals, Inc. (Prime)

Participants: Eastman Chemicals (Sub-contractor)
Bechtel (Sub-contractor)
Lehigh University (Sub-contractor)
University of Delaware (Sub-contractor)
Aachen University (Sub-contractor)
University of Trondheim (Sub-contractor)

Title: Alternative Fuels and Chemicals from Synthesis Gas

Justification: The project was awarded to develop a range of indirect liquefaction technologies to produce alternative fuels and chemicals from coal-derived synthesis gas. Air Products and Chemicals (APCI), the prime contractor, is the developer of the liquid phase methanol technology and, thus, uniquely qualified for the extension of this technology to other applications. The other industrial team members include Eastman Chemicals, which is the world leader in syngas-based chemicals producer; and Bechtel, which is a prime engineering company with a R&D group interested in the participation of development of emerging technologies in refining and chemicals areas. The joint efforts by the lab researchers and industrial members in the same program will greatly enhance the speed to commercialize the technologies developed under this program.

Contractor 2: Air Products and Chemicals, Inc. (Prime)

Participants: Washington University (Sub-contractor)
Ohio State University (Sub-contractor)

Title: Engineering Development of Slurry Bubble column Reactor Technology

Justification: The objective of this work is to develop a database for the design of commercial-scale slurry bubble column reactors also known as liquid phase reactors. The scope of work includes experimental work at bench and LaPorte proof-of-concept scale units, as well as reactor modeling development. Air Products and Chemicals, Inc (APCI), the prime contractor, is uniquely qualified for this work because of its extensive experience in liquid-phase reactor technology including the operation of the reactor at LaPorte. It will be assisted by two sub-contractors of Washington University at St Louis and Ohio State University. Both subcontractors are known to be the experts in three phase reactor fluid dynamics, including reactor modeling, and have the equipment already in place for the proposed experimental work. The members of this team should complement each other in the successful development of a model for reactor scale-up.

Contractor 3: Texas A&M University

Title: Fischer-Tropsch Iron Catalyst Development

Justification: This project was awarded as a follow-up for a prior contract awarded under a competitive procurement. The scope of work is to further pursue the two most promising iron catalysts developed under the prior contract. The proposer has the know-how and facility in the catalyst preparation and testing, and is uniquely qualified for this proposed work.

Contractor 4: Kentucky Center for Applied Energy Research

Title: Technology Development for Iron Fischer-Tropsch Catalysts

Justification: This project was awarded as a follow-up for a prior contract awarded under a competitive procurement. In this program, the proposer will team up with the United Catalyst Company to scale up the production of the most promising iron catalysts from prior contract on a semi-commercial scale unit. These catalysts will then be tested with the aim to qualify them for further tests to be done in the LaPorte proof-of-concept unit. The proposer is uniquely qualified for the work due to its past experience and close working relationship with a commercial catalyst company.

Contractor 5: Mitretek

Title: Research Guidance Studies

Justification: This project was awarded because of the expertise that Mitretek can offer the DOE in performing research guidance studies for both direct and indirect liquefaction programs. Mitretek has developed an in-house computer model and an extensive database to perform research guidance studies for various coal liquefaction conversion technologies.

Q20. Please describe the "coal liquids end use and emissions study" (page 33 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995 and FY 1996).

A20. The objective of the "coal liquids end use and emissions study" is to develop a database for the coal liquids to be used as part of the crude mix in a conventional refinery. The scope of work includes the co-refining of crude and coal liquids, engine emission tests of co-refined products, and modification of a generic refinery operation model to incorporate the use of coal liquids. The final deliverable will be a data package which defines the preferred options for upgrading coal liquids in the refinery to optimize the their value. The coal liquids used in this study were produced from the proof-of-concept (POC) units at LaPorte (Texas). The prime contractor is Bechtel and sub-contractors are Southwest Research Institute, Kellogg, and Amoco.

Q21. Please describe the "research guidance at Mitretek" (page 33 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1996 and FY 1997).

A21. Mitretek has developed a computer model to perform scoping economic studies for a conceptual commercial indirect liquefaction plant. The model has proved effective as a tool to provide answers to the "if and what" scenarios for coal liquefaction R&D. The research guidance from these studies has been essential for DOE to implement its Indirect Coal Liquefaction Program in a cost- efficient manner. The good rapport and respect which Mitretek has established with the DOE contractors and other interested organizations doing research in coal liquefaction is an important ingredient for the success of their work.

Q22. Please describe the "technical and program management support" (page 34 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A22. The technical and program management support activity assists the Indirect Liquefaction Program by providing coal technology systems studies, and analyses and market assessments to assist in the strategic planning, prioritization and decision-making process for the Coal Technology Program. The support activity also provides program information and technology assessments of international competitors to assess their progress, degree of emphasis, and program direction. In addition, the technical and management support activities provide logistical and facilitates assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback to coal technology strategy and planning.

Advanced Research and Environmental Technology

Q23. Please provide a listing of the recipients of (i) the $3,895,000 in funding in FY 1995, (ii) the $3,546,000 in FY 1996 funding, and (iii) the requested level of $746,000 in FY 1997 for Advanced Research and Environmental Technology, including the funding for each recipient.

A23.

Advanced Research and Environmental Technology Funding Recipients

Recipients	FY 1995	FY 1996	FY 1997
Consortium for Fossil Fuel Liquefaction Science (CFFLS)	$1,700,000	$1,700,000	$0
Penn State University	$156,000	$124,000	$0
Sandia National Laboratories	$402,000	$480,000	$421,000
PETC In-House	$1,538,000	$1,142,000	$318,000
Burns & Roe Support	$59,000	$65,000	$0
Headquarters	$40,000	$35,000	$7,000
Total	**$3,895,000**	**$3,546,000**	**$746,000**

Q24. For each recipient of Advanced Research and Environmental Technology funds identified in the response to question 23 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A24.

Advanced Research and Environmental Technology Funding Recipient Cost-Sharing

Recipients	FY 1995	FY 1996	FY 1997
Consortium for Fossil Fuel Liquefaction Science (CFFLS)	$1,458,000	$1,460,000	$0
Penn State University	$0	$0	$0
Sandia National Laboratories	$0	$0	$0
PETC In-House	$0	$0	$0
Burns & Roe Support	$0	$0	$0
Headquarters	$0	$0	$0
Total	**$1,458,000**	**$1,460,000**	**$0**

Q25. For those Advanced Research and Environmental Technology funding recipients listed in the response to question 23 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A25. Non-Competitive Awards:

Recipient/Justification:

CFFLS–Congressionally directed; only performers for advanced research in coal liquefaction and waste coprocessing related to DOE programs.

Sandia National Laboratories–Only location where kinetic studies on nanometer-size iron catalysts and where a standard catalyst testing program exists.

Penn State University–Only facility that collects samples of coals and characterizes them for use by DOE contractors.

Q26. Please describe the "technical and program management support" (page 34 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A26. To provide funding for: technical assessments and analyses of Office of Fossil Energy's research program; preparation of briefing materials, program planning and strategic planning documents; comprehensive peer review of FE's advanced research projects; administering DOE's Homer H. Lowry Award; and contributing pro rata share of computer/computer support, LAN and budget planning and execution support costs.

Systems for Coproducts

Q27. Please provide a listing of the recipients of the $90,000 in funding in FY 1995 for Systems for Coproducts, including the funding for each recipient.

A27.

	FY 1995
METC In-house Research	$40,000
HQ Program Management Support	$50,000
Gilbert-Commonwealth	
PEDDADA	

Q28. For each recipient of Systems for Coproducts funds identified in the response to question 27 above, please provide the level of funding provided by that recipient as cost-sharing for FY 1995.

A28. None of these contracts has cost sharing.

Q29. For those Systems for Coproducts funding recipients listed in the response to question 27 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A29. The contract for the two private sector recipients identified were not on the basis of a non-competitive award.

COAL: ADVANCED CLEAN/EFFICIENT POWER SYSTEMS

Advanced Pulverized Coal-Fired Powerplant

Q30. Please describe the Low-Emission Boiler System (LEBS) work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A30. The Low Emission Boiler System (LEBS) is a highly advanced pulverized-coal-fired powerplant intended to provide the U.S. electric power industry with a reliable, economic, efficient, and environmentally sound alternative to current technologies. LEBS is an evolutionary step in the development of industry-proven pulverized-coal-fired power generating systems. Using a systems approach, LEBS derives maximum benefit from recent advances in low-NO_x combustion, flue gas cleanup technology, and materials for boiler tubes. Additionally, the program includes powerplant cycles based on both supercritical steam and steam-ammonia mixtures (Kalina Cycle).

The product of the LEBS Program will be the commercial capability for a coal-based electricity generating system for new or replacement capacity, by the year 2000, with the following performance characteristics:

SO2:	0.1
NO_x:	0.1
Particulates:	0.01
Efficiency:	42% by 2000; 45% by 2010 with supercritical steam cycles; 45-50% by 2000 with the Kalina cycle
Cost of electricity:	less than current coal-fired plant designed to meet New Source Performance Standards

ABB-Combustion Engineering, Babcock & Wilcox and DB Riley are leading teams that are competing to develop the best power system. Each team is pursuing a very different approach. The ABB/CE firing technique is a major advancement of its tangential firing system, but incorporates low-NO_x, coal nozzles and deep staging/reburning. B&W's firing technique employs an advanced low NO_x burner derived from a commercial low NOx burner design. Riley's firing system is being adapted from a commercial slagging design that is being reworked to produce low NO_x emissions. The new firing system incorporates deep staging/reburning and produces vitrified ash.

In the LEBS concepts, gas cleaning for SO_2 and/or NO_x is integrated in ways to reduce parasitic power and heat losses. ABB/CE is developing a SNO_x ™ hot process, an adaptation of its combined SO_2 and NO_x removal process, that was demonstrated successfully in DOE's Clean Coal Technology Program. The advanced version operates at a higher temperature so that the flue gas does not need to be cooled and subsequently reheated. This results in higher efficiency operation. B&W uses its limestone injection dry scrubbing (LIDS) process, which integrates three commercially proven flue gas cleaning techniques–furnace limestone injection, dry scrubbing, and pulse-jet fabric filtration. Riley's choice for flue gas cleanup (SO_2 and NO_x) includes a moving bed copper oxide absorber previously tested at bench scale.

The LEBS program is a phased research and development program that includes four Phases:

- Phase I, Systems Analysis, R&D Plan Formulation, Component Development, and Preliminary Commercial Plant Design. The industry teams have evaluated and selected candidate technologies; identified design uncertainties and development needs; conducted engineering analysis, modeling and preliminary, small-scale experimental work. By the end of FY 94, the teams had completed a preliminary design and economic analysis of their commercial-scale LEBS plants and had defined the work to be undertaken in Phase II.

- Phase II, Engineering Development and Testing. Work began early in FY 95 and includes the development of components and construction and testing of plant subsystems on about the 3-10 MWe scale. Major technical issues are being resolved before proceeding to the design and construction of the larger scale proof-of-concept (POC) facility. Phase II will conclude at the end of FY 96.

- Phase III, POC Test Facility Design. Results of Phase II will be used to update the commercial plant design and economics and to develop an engineering design and test plan for the POC facility, 10-50 MWe in size. No more than one contractor will be authorized to proceed to Phase IV.

- Phase IV, POC Test Facility Construction and Operations. One contractor team will prepare a detailed design for the POC plant, and then construct and operate the POC facility. Contractor selection for Phase IV will depend greatly on the degree to which Phase II subsystem testing verifies performance predictions and reduces technical uncertainties, and the subsequent design of the POC facility produced during Phase III.

The three contractor teams, at the end of Phase I, had analyzed various technologies and alternative methods for their integration into the total system to meet the performance goals. Conceptual system designs that will meet or exceed the performance goals are now available.

In Phase II, developmental firing and flue gas treatment subsystems are being operated at conditions which simulate their integration into the LEBS concepts to verify performance predictions.

Program cost to date (through FY96)		Expected cost of completion:[1]	
DOE	$33.1M	DOE	$32.1M
Industry	$ 7.7M	Industry	$28.7M
Total	$40.1M	Total	$60.8M

[1] Based on an average of the three teams' cost estimates for Phase IV

Q31. On page 193 of the National Research Council report *Coal: Energy for the Future* it is stated that ". . . LEBS offers comparatively small potential to evolve to a significantly higher performance system. . .".

Q31a. Does DOE concur with this assessment, and if not why not?

A31a. DOE does not concur with this assessment. The original target efficiency for the LEBS Program was 42 percent for the year 2000, but this does not represent the ultimate efficiency for the LEBS system. Beyond 2000, improved materials for higher temperature and pressure supercritical steam cycles will permit LEBS to achieve 45 to 50 percent efficiency in the 2010 time frame.

Q31b. If DOE concurs with this assessment, why is LEBS being pursued?

A31b. Not applicable, since DOE does not concur with the National Research Council assessment.

Q32. Please provide a listing of the recipients of (i) the $7,329,000 in funding in FY 1995, (ii) the $10,600,000 in FY 1996 funding, and (iii) the requested level of $5,500,000 in FY 1997 for Advanced Pulverized Coal-Fired Powerplant, including the funding for each recipient.

A32.

Advanced Pulverized Coal-Fired Powerplant Funding Recipients

Recipients	**FY 1995**	**FY 1996**	**FY 1997**
DB Riley	$2,097,000	$1,941,000	$2,532,000
ABB-CE	$2,097,000	$2,772,000	$1,449,000
B&W	$2,096,000	$4,791,000	$1,160,000
Energy & Environmental Research	$61,000	$0	$0
Donlee	$147,000	$990,000	$0
ThermoChem	$756,000	$0	$0
TBD (LEBS Phase IV)	$0	$0	$219,000
Parsons Power	$75,000	$106,000	$140,000
Total	**$7,329,000**	**$10,600,000**	**$5,500,000**

Q33. For each recipient of Advanced Pulverized Coal-Fired Powerplant funds identified in the response to question 32 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A33.

Advanced Pulverized Coal-Fired Powerplant Funding Recipient Cost-Sharing

Recipients	**FY 1995**	**FY 1996**	**FY 1997**
DB Riley	$699,000	$658,000	$833,000
ABB-CE	$699,000	$935,000	$472,000
B&W	$699,000	$1,607,000	$376,000
Energy & Environmental Research	$18,000	$0	$0
Donlee	$11,000	$74,000	$0
ThermoChem	$19,000	$0	$0
Parsons Power	$0	$0	$0
Total	**$2,145,000**	**$3,274,000**	**$1,681,000**

Q34. For those Advanced Pulverized Coal-Fired Powerplant funding recipients listed in the response to question 32 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A34. The following recipient was awarded funds on a noncompetitive basis:

Recipient: ThermoChem, Inc.

Justification: The Morgantown Energy Technology Center awarded a cooperative agreement to the recipient on a restricted basis after evaluation of its unsolicited proposal for a pulsed atmospheric fluidized bed combustor (PAFBC). This unsolicited proposal meets the criteria for selection in accordance with DOE Assistance Regulation IO CFR 600.14.

Section 253(c) (1) of the Competition in the Contracting Act of 1984 allows for other than full and open competition when supplies or services are available from only one source, and no other type of supplier or services will satisfy the Agency requirements.

The pulsed fluidized-bed concept is a unique and innovative coal-fueled technology that has the potential to provide heat and/or process steam to small industrial, commercial, institutional, and residential complexes. Under this proposal, ThermoChem tested the PAFBC technology under adiabatic and non-adiabatic conditions. This is a unique application of the technology. These aspects of the operation of the PAFBC have never been tested under any conditions.

Q35. On page 39 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1997, it is stated: "Implement customer service activities ($85)."

Q35a. Which specific "customers" are going to be provided "service"?

A35a. The LEBS program will result in the operation of a 25 MW prototype plus a conceptual design of a commercial scale plant. The purpose of providing support for this activity is that significant national benefits can be derived by commercializing the technology. Specific customers include electric utility companies, independent power producers, and equipment manufacturers.

Q35b. Who specifically is going to "provide" this "customer service"?

A35b. The reference to "customer service" is an activity conducted by the DOE program manager to work with prospective users of the technology to acquaint them with the characteristics of the technology and to encourage them to use the technology where it satisfies a need for power. This activity can consist of participation in conceptual designs and supporting analytical efforts.

Q36. Please describe the "technical and program management support" (page 39 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A36. The technical and program management support activity in the Advanced Pulverized Coal-Fired Powerplant program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization and decision-making process for the program. In addition, the technical and management support activities provides logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the Advanced Pulverized Coal-Fired Powerplant program strategy and planning.

Indirect Fired Cycle

Q37. Please describe the High Performance Power Systems (HIPPS) work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A37. Description of Work and Progress

The HIPPS program began in 1992 when, as the result of a competitive procurement, contracts for Phase I were awarded to industry teams to begin developing advanced power systems based on the indirectly fired cycle. The teams were led by Foster Wheeler Development Corporation (FWDC) and United Technologies Research Center (UTRC). As the result of a second competitive procurement conducted during 1994-95, Foster Wheeler and United Technologies were selected in June 1995 to complete the development of HIPPS (Phases II and III).

Phase I of HIPPS is complete. Phase I was focused on the analysis of various configurations of indirectly fired cycles and on technical assessments of alternative plant subsystems and components, including performance requirements, development status, design options, complexity and reliability, and capital and operating costs. Phase I also included preliminary R&D, and the preparation of a design for a HIPPS commercial plant, approximately 300 MWe in size. Estimates of the thermal efficiency for a HIPPS commercial plant were confirmed by engineering analysis to be in the 47-50% range. Significant Phase I R&D accomplishments included the successful testing by UTRC team of a radiant heat exchanger panel in a coal-fired furnace, and completion by the FWDC team of pyrolyzer testing and char combustion testing.

Phase II, which began in August 1995, includes the testing and analysis that is required to develop the technology base for a prototype HIPPS plant. The Phase II effort is expected to take about 4 1/2 years and end in February 2000. The major product will be two site-specific designs for the HIPPS prototype plant. After evaluating the designs, DOE will select one of the two industry teams to proceed to Phase III, during which the selected team will prepare a detailed design of the HIPPS prototype, and construct and operate the plant.

Costs

High Performance Power Systems (HIPPS) Phase I and Phase II Costs
($ millions).

	Phase 1		**Phase II**	
	DOE	Private	DOE	Private
FWDC	6.1	0	33.3	8.3
UTRC	5.9	0	29.1	7.7
Total	**12.1**	**0**	**62.4**	**16.0**

Phase III: DOE costs for Phase III are estimated at $50 million over 5 years. Cost sharing will be 50%.

	PRE-95	**FY95**	**FY96**	**FY97***
FWDC	DOE: 6.1 Private: 0	DOE: 3.6 Private: 0.9	DOE: 5.2 Private: 1.3	DOE: 8.6 Private: 2.2
UTRC	DOE: 5.9 Private: 0	DOE: 3.6 Private: 0.9	DOE: 5.2 Private: 1.3	DOE: 6.0 Private: 1.5
Total	**DOE: 12.0** **Private: 0**	**DOE: 7.2** **Private: 1.8**	**DOE: 10.4** **Private: 2.6**	**DOE: 14.6** **Private: 3.7**

*Funding needed to maintain schedule.

Q38. Please provide a listing of the recipients of (i) the $11,584,000 in funding in FY 1995, (ii) the $11,900,000 in FY 1996 funding, and (iii) the requested level of $11,005,000 in FY 1997 for Indirect Fired Cycle, including the funding for each recipient.

A38.

Indirect Fired Cycle Funding Recipients

CONTRACTOR	FY 1995	FY 1996	FY 1997
United Technologies Research Center	$3,606,000	$5,228,000	$3,920,000
Foster Wheeler Development Corp.	$3,579,000	$5,228,000	$5,600,000
Hague International	$2,590,000	$0	$0
METC In-House	$641,000	$0	$0
PETC In-House	$675,000	$950,000	$950,000
Burns & Roe	$375,000	$375,000	$375,000
Parsons Power	$118,000	$119,000	$160,000
Total	**$11,584,000**	**$11,900,000**	**$11,005,000**

Q39. For each recipient of Indirect Fired Cycle funds identified in the response to question 38 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A39.

Indirect Fired Cycle Funding Recipient Cost-Sharing

CONTRACTOR	FY 1995	FY 1996	FY 1997
United Technologies Research Center	$902,000	$1,308,000	$980,000
Foster Wheeler Development Corp.[1]	$951,000	$1,308,000	$1,400,000
Hague International	$600,000	$0	$0
Burns & Roe	$0	$0	$0
Parsons Power	$0	$0	$0
Total	**$2,453,000**	**$2,616,000**	**$2,380,000**

[1] 5% in foregone fee is not included in table.

Q40. For those Indirect Fired Cycle funding recipients listed in the response to question 38 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A40. Recipient: Hague International.

Justification: An unsolicited proposal was offered by Hague International in 1989. No other company at that time had formed a cost-sharing consortium and funded preliminary heat exchanger component test work on their own. The inherent advantages of the indirect-fired cycle (separation of contaminated flue gas from the turbine) and the successful experience of Hague in the ceramic heat exchanger business led to a Cooperative Agreement with Hague in 1990. This award was justified under Section 253(c)(1) of the Competition in the Contracting Act of 1984 which allows for other than full and open competition when supplies or services are available from only one source, and no other type of supplier or services will satisfy the Agency requirements.

Q41. Please describe the "customer service" reference for FY 1997 on page 40 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request.*

A41. The Indirect Fired Cycle will result in the operation of a proof-of-concept High Performance Power System. The purpose of providing support for this activity is that significant national benefits can be derived by commercializing this technology.

The reference to "customer service" is an activity conducted by the DOE program manager to work with prospective users of the technology (i. e., electric utilities, independent power producers and equipment manufacturers) to acquaint them with the characteristics of the technology and to encourage them to use the technology where it satisfies a need for power. This activity can consist of participation in conceptual designs and supporting analytical efforts.

Q42. Please describe the "project management support" (page 40 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A42. Program support provides technical services that encompass activities in the following three areas:

- Technical Management
    - Organize and conduct meetings, workshops, and conferences including participating in the event.
    - Prepare manuscripts for publication or briefing purposes.

- Technical Assessment
    - Monitor and report the status of current and emerging technologies that are relevant to the program areas.
    - Identify research and development needs and opportunities and provide recommendations for addressing key technical issues.
    - Review technical and cost data developed in projects that are being funded by DOE.

- Engineering Support
    - Perform engineering and economic studies to assist program planning efforts.
    - Participate in teams that assess and advise program planning efforts.

Q43. Please describe the "technical and program management support" (page 40 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A43. The technical and program management support activity in the Indirect Fired Cycle program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization and decision-making process for the program. In addition, the technical and management support activities provide logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the Indirect Fired Cycle program strategy and planning.

High Efficiency - Integrated Gasification Combined Cycle

Q44. Please describe the Integrated Gasification Combined Cycle work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A44. The Advanced IGCC Power Systems "developmental cycle" was begun with applied research addressing concept validation, followed by R&D activities that have led to first-of-a-kind demonstration-scale projects embodied in the DOE Clean Coal Technology Program. The DOE has invested in high-risk R&D that has successfully identified, addressed, and resolved many technical barriers, thus allowing the development of a high temperature, high-efficiency power generation plant with much reduced environmental emissions of pollutants such as sulfur dioxide, nitrogen oxides, carbon dioxide, and solid waste.

DOE funding of the high-risk R&D cycle ranged from 80 to 100 percent of the development cost depending on maturity level and industry's willingness to co-fund the R&D. Presently, Destec, Texaco, and KRW gasification technology are just starting or nearing startup of first-of-a-kind commercial scale IGCC demonstration. These projects are possible as least-cost, electric-supply options only because of DOE cost sharing for the first-of-a-kind plants being built and initially operated under the CCT Program. Maximum DOE funding is 50 percent of demonstration cost.

The advanced, high temperature, high-efficient subsystems and components included in these plants would not be available nor would the technology of the projects have been sufficiently mature to meet the CCT selection criteria without DOE-funded R&D. Federal funding of the advanced high temperature IGCC R&D activities through FY 1997 will be $201,000,000.

Management of the IGCC R&D Program has provided technical benefits to other advanced power generation development such as Pressurized Fluid-Bed Combustion, Fuel Cells, Externally Fired Cycles, and Advanced Turbine Systems; additionally, developments in these programs have also provided benefits to IGCC technology. Opportunities to coordinate technical activities of other Federal R&D Programs have been exploited, thus, leveraging the development of technical information to many technological areas. DOE funding of the IGCC CCT projects will be $816,386,000; industrial cost share will be $1,302,867,000 when the projects are completed. Under the terms of the CCT awards, the Federal investment will be recouped as these specific technologies are sold to the domestic and global market.

In "Foreign Markets for U.S. Clean Coal Technologies - Report to the United States Congress by the United States Department of Energy" (DOE/FE-0317, page 1-3), the potential market for clean coal technologies "for new facilities, retrofit installation and follow-on work is estimated to range from $571 billion to $870 billion..." Using a conservative share of the international opportunities, the potential IGCC market is estimated to be more than $400 billion by the year 2030. The domestic market is projected to be about $150 billion by the year 2030.

Government leadership is required in product improvements that will reduce technology risk, plant capital and operating cost, improve plant efficiencies, and further reductions of environmental emissions compared to the first-of-a-kind plants. If the U.S. were to ignore the needs of this product development and abandon advanced IGCC at this critical time, other governments will intercede at a relatively low cost buy-in to harvest the U.S. IGCC investment.

Q45. Please provide a listing of the recipients of (i) the $25,810,000 in funding in FY 1995, (ii) the $22,000,000 in FY 1996 funding, and (iii) the requested level of $22,500,000 in FY 1997 for High Efficiency - Integrated Gasification Combined Cycle, including the funding for each recipient.

A45. A listing of the recipients of the funding in FY 1995-FY 1997 is provide in the following table:

High Efficiency - Integrated Gasification Combined Cycle
Funding Levels - Thousands of Dollars

Contractor	**Contract No.**	**FY95**	**FY96**	**FY97**
**Southern Company Services	25140	12,806	12,000	10,000
**General Electric	*23170	1,515	1,771	2,500
**General Electric	33053	0	879	400
General Electric	31089	154	617	211
**Research Triangle Institute	25006	365	382	0
**Research Triangle Institute	29011	0	68	200
Research Triangle Institute	*30010	359	50	300
Research Triangle Institute	31258	133	161	489
Phillips Petroleum Company	*32266	0	207	0
SRI International	30005	231	85	0
Coal Tech. Research Corp.	24116	100	200	0
Lawrence Berkeley Lab	32064	30	0	0
Hampton College	31393	0	40	0
UND Energy & Env.	30097	302	500	500
Oak Ridge National Lab	32066	20	0	0
Sensor Research	32196	48	0	0
METC In-House	99999	6,142	4,292	4,775
**Sorbent Integration	33018	0	0	2,700
**Thermochem, Inc.	*27229	1,448	0	0
**Donlee Technologies, Inc.	27205	1,200	0	0
K&M Eng. & Consulting	27346	480	0	0
K&M Eng. & Consulting	32268	152	0	0
Ames Lab	20104	50	0	0
Ames Lab	33104	0	110	0
Total		**25,535**	**21,362**	**22,075**

*Non-Competitive Procurement
**Cost-Sharing Recipient

Q46. For each recipient of High Efficiency - Integrated Gasification Combined Cycle funds identified in the response to question 45 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A46. A listing of the recipients of the funding in FY 1995-FY 1997 and the level of funding provided by that recipient as cost-sharing for FY 1995-FY 1997 is given in the following table:

High Efficiency - Integrated Gasification Combined Cycle "Cost-Shared Recipients"
Funding Levels - Thousands of Dollars

Contractor	**Contract No.**	**FY95**	**FY96**	**FY97**	**Cost Share FY95-97**
So. Company Services	25140	12,806	12,000	10,000	4,525
GE	23170	1,515	1,771	2,500	636
GE	33053	0	879	400	255
RTI	25006	365	382	0	24
RTI	29011	0	68	200	6
Sorbent Integration	33018	0	0	2,700	540
ThermoChem	27229	1,448	0	0	43
Donlee	27205	1,200	0	0	84
Total		17,334	15,100	15,800	6,113

Q47. For those High Efficiency - Integrated Gasification Combined Cycle funding recipients listed in the response to question 45 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A47. Justification for non-competitive awards is as follows:

Desulfurization Sorbent (Contract #32266). This activity purchased 110,000 pounds of a proprietary IGCC hot gas cleanup desulfurization sorbent from Phillips Petroleum Company. The sorbent was the only one commercially available for use in an IGCC system, and the patent is owned by Phillips. Phillips will provide the sorbent to DOE by establishing licensing agreements with at least two commercial manufacturers, provide QA/QC during the manufacturing process, and will obtain at least two competitive bids.

General Electric (Contract #33053). This activity is developing an IGCC hot gas cleanup system. GE was the sole source of a gasifier pilot plant that would produce a low-Btu fuel gas to continue development of a moving-bed desulfurization system. The moving-bed cleanup system is paten-Led by GE, and is now being demonstrated in the Clean Coal Technology Program.

Research Triangle Institute (Contract #33010). This activity is developing an innovative process to recover elemental sulfur as a valuable byproduct from an IGCC powerplant. RTI holds rights in the process patent. The expertise and facilities supporting this process were available only at RTI.

ThermoChem, Inc (Contract #27229). This activity is to establish the proof-of-concept and commercialization of the pulsed atmospheric fluidized-bed combustion system, a unique and innovative coal-fueled technology that has potential to provide heat and process steam to small industrial, commercial, institutional, and residential customers. That work which is done in the atmospheric combustion environment is considered to be immediately applicable to the pulse combustor's use in an advanced gasification system. The pulsed combustor is an integral part of the pulsed indirect coal gasification concept for IGCC application. Conduct of 0the DE-FC21-90MC27229 Cooperative Agreement will simultaneously and cost effectively address the successful demonstration of the pulsed combustor within an IGCC operation.

Q48. On page 41 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1996 and FY 1997, it is stated: "Implement customer service activities."

Q48a. Which specific "customers" are going to be provided "service"?

Q48b. Who specifically is going to "provide" this "customer service"?

A48. Utility companies and independent power producers will be provided with the services. The purpose of providing support for this activity is that significant national benefits can be derived by commercializing the technology.

The reference to "customer service" is an activity conducted by the DOE program manager to work with prospective users of the High Efficiency - Integrated Gasification Combined Cycle technology to acquaint them with the characteristics of the technology and to encourage them to use the technology where it satisfied a need for power. This activity can consist of participation in conceptual designs and supporting analytical efforts.

Q49. Please describe the "technical and program management support" (page 42 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A49. The technical and program management support activity in the High-Efficiency Integrated Gasification Combined Cycle Program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization, and decision-making process for the program. The support activities also provide program information and technology assessments of international competitors to assess their progress, degree of emphasis, and program direction in the integrated gasification combined cycle area. In addition, the technical and management support activities provide logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the High-Efficiency Integrated Gasification Combined Cycle Program strategy and planning.

High Efficiency - Pressurized Fluidized Bed

Q50. Please describe the Pressurized Fluidized Bed work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A50. To date a small prototype unit has been developed by Foster-Wheeler in Livingston, New Jersey and tested. Critical components (hot gas filtration, compressor/turbine module), and system integration at pilot scale will be tested at the Power System Development Facility (PSDF) and hot gas filtration systems are being developed. The total cost of the development at the Livingston, N.J. facility to date has been about $42 million, of which about 10% has been contributed by the private sector. During the next three years, this advanced power system will be tested at the Southern Company Services PSDF located in Wilsonville, Alabama. The total DOE funding for advanced PFBC including the Foster Wheeler development at Livingston, hot gas filter development and PSDF (cost-sharing of 20% by participants) is $165.5 million. The estimated cost to complete the advanced PFBC is $32 million. The advanced PFBC system might lead to a demonstration plant at the pilot scale capable of achieving 45 percent efficiency and emission levels of 1/10 of NSPS. This developmental effort is providing the data needed for three Clean Coal Technology demonstrations and for commercialization. The worldwide market potential for this technology in the next 35 years is estimated to be $480 billion.

Q51. Please provide a listing of the recipients of (i) the $24,764,000 in funding in FY 1995, (ii) the $19,500,000 in FY 1996 funding, and (iii) the requested level of $18,000,000 in FY 1997 for High Efficiency - Pressurized Fluidized Bed, including the funding for each recipient.

A51. Fiscal Year funding for recipients is listed in the table below:

High Efficiency - Pressurized Fluidized Bed Funding Recipients and Cost-Sharing
(In Thousands of Dollars)

Contractor Contract Number	FY95 DOE Contractor	FY96 DOE Contractor	FY97 DOE Contractor
In-House Research (OTBD), 99999	1,400 na	2,070 na	2,350 na
In-House Research (PPE), 99999	50 na	210 na	650 na
UNDEERC, 30097	0 0	350 0	0 0
Westinghouse, 31147	476 0	800 0	345 0
Southern Research Institute, 31160	200 0	500 0	400 0
BIRL, 32085	100 0	60 0	0 0
Oak Ridge National Lab, 32099	21 0	0 0	0 0
Westinghouse, 24257	0 0	24 0	0 0
Combustion Power Co., 27423	0 0	46 0	0 0
Parson's Engineering, 31166	0 0	100 0	0 0
Westinghouse, 31167	271 68	461 115	110 27.5
B&W, 31212	53 13	172 43	200 50
Textron Corp., 31213	89 22	243 61	245 61
Dupont Corp., 31214	105 26	202 50.5	0 0
Pall Aerospace Corp., 31215	300 75	300 75	50 12.2

Contractor Contract Number	FY95 DOE Contractor	FY96 DOE Contractor	FY97 DOE Contractor
Oak Ridge National Lab, 33106	0 0	47 0	0 0
American Electric Power, 26042	1,800 450	0 0	0 0
Foster Wheeler Corp., 21023	2.500 278	850 94	1.000 111
MTCI, 26288	484 0	0 0	0 0
University of Iowa, 28081	50 0	0 0	0 0
Southern Company Services, 25140	16,418 20%	12.000 20%	12.000 20%
ThermoChem, 27229	195 61	0 0	0 0
To Be Determined, 33007	0 0	400 100	0 0
HQ Prog. Tech. & Mgmt Support	253 na	195 na	180 na
Customer Service Activities	0 na	0 na	250 na
Total	24,764	19.500	18,000

Note: Top Amount - Contract Amount; Bottom Amount - CoShare.

Q52. For each recipient of High Efficiency - Pressurized Fluidized Bed funds identified in the response to question 51 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A52. Please see question 51 for the cost sharing provided by recipients.

Q53. For those High Efficiency - Pressurized Fluidized Bed funding recipients listed in the response to question 51 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A53. Listed below are those recipients which were awarded funds on a noncompetitive basis.

Recipient 1: BIRL Industrial Research Lab

Justification: The Morgantown Energy Technology Center awarded a contract to the recipient after evaluation of its unsolicited proposal to provide analysis of ceramic component development technologies currently being developed for utilization in advanced powerplants. Section 253(c)(1)of the Competition in the Contracting Act of 1984 allows for other than full and open competition when supplies or services are available from only one source, and no other type of supplies or services will satisfy the agency requirements.

BIRL's expert and world renown staff will participate in this effort. The staff has developed a process, being patented, to deposit ceramic coatings by thermal spray and recognized expertise in ceramic property-structure relationships that are unique to the BIRL organization

Recipient 2: American Electric Power Service Corporation, Columbus, Ohio

Justification: The American Electric Power Service Corporation (AEPSC) submitted an unsolicited proposal to the Morgantown Energy Technology Center that upon evaluation led to a cooperative agreement. The purpose of the cooperative agreement was to evaluate integrated engineering designs of selected advanced particulate control technologies by proof-of-concept testing at an operating pressurized fluidized bed combustion (PFBC) facility. It was determined that eligibility for a financial assistance award would be restricted to only one applicant. This proposal was not eligible for financial assistance under any recent, current, or planned DOE solicitation at the time, and a competitive solicitation would not be appropriate due to the use of the AEPSC Tidd pressurized fluidized-bed combustion facility, which was the only facility of adequate size available for performing the proposed research. This determination was made pursuant to 10 CFR Part 600.7(b)(2) which sets forth the criteria: "The applicant has exclusive domestic capability to perform the activity successfully based upon unique equipment, proprietary data, technical expertise, or other such unique qualifications." The distinguishing feature of the proposed AEPSC effort was the availability of the Tidd-PFBC facility.

Recipient 3: ThermoChem, Inc., Columbia, Maryland

Justification: See Q34.

Recipient 4: Southern Company Services, Inc., Birmingham, Alabama.

Justification: Southern Company Services, Inc. (SCS) submitted a proposal to evaluate integrated engineering designs of selected advanced particle control technologies through proof-of-concept testing. A dirty gas reactor will produce gas representative of PFBC or IGCC conditions. This application was initially submitted under the FY 1989 Morgantown Energy Technology Center Broad Agency Announcement (BAA). Due to the nature of the proposed work, it was determined that the BAA was not the appropriate solicitation vehicle. Therefore, since the application was not specifically solicited, and no significant preapplication contact was made, it was determined that the proper contractual vehicle should be a noncompetitive financial assistance pursuant to 10 CFR Part 600.7(b)(2). The criteria for such determination states: "The applicant has exclusive capability to perform the activity successfully based upon unique equipment proprietary data, technical expertise or other such unique qualifications." The SCS Power Systems Development Facility provides a unique opportunity to evaluate selected advanced particle control technologies using a proprietary dirty gas source reactor.

Recipient 5: Westinghouse Electric Corporation, Science and Technology Center, Pittsburgh, Pennsylvania.

Justification: This was a sole source acquisition because the subject follow-on contract would provide for continuing performance under a new work scope. Competitive procurement is not feasible based upon economic and technical reasons. Section 303(c)(1)(b), which allows in the case of a follow-on contract for the continued development or production of a major system or highly specialized equipment when it is likely that award to a source other than the original source would result in substantial duplication of cost to the Government which is not expected to be recovered through competition. The research to be conducted will include laboratory and bench scale experiments designed to understand the response of advanced ceramic filter materials when exposed to PFBC and IGCC process conditions.

Q54. On page 42 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1997, it is stated: "Implement customer service activities ($250)."

Q54a. Which specific "customers" are going to be provided "service"?

A54a. Specific customers are:

- Electric Utility Companies
- Independent Power Producer
- Co-generator Companies

Q54b. Who specifically is going to "provide" this "customer service"?

A54b. The reference to "customer service" is an activity conducted by the DOE program manager to work with prospective users of the High Efficiency - Pressurized Fluidized Bed Technology to acquaint them with the characteristics of the technology and to encourage them to use the technology where it satisfies a need for power. This activity can consist of participation in conceptual designs and supporting analytical efforts.

Q55. Please describe the "technical and program management support" (page 43 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A55. The technical and program management support activity in the High Efficiency - Pressurized Fluidized Bed program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization and decision-making process for the program. The support activities also provide program information and technology assessments of international competitors to assess the progress, degree of emphasis and program direction in the High Efficiency - Pressurized Fluidized Bed area. In addition, the technical and management support activities provides logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the High Efficiency - Pressurized Fluidized Bed program strategy and planning.

Advanced Research and Environmental Technology

Q56. Please provide a listing of the recipients of (i) the $18,169,000 in funding in FY 1995, (ii) the $14,284,000 in FY 1996 funding, and (iii) the requested level of $9,802,000 in FY 1997 for Advanced Research and Environmental Technology, including the funding for each recipient.

A56.

Advanced Research and Environmental Technology Funding Recipients
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
METC	1,250	800	221
CTC	100	0	0
UNDEERC	324	237	194
ANL	600	650	0
ERC	118	0	0
ARCTECH	50	0	0
Ames	270	170	0
Dravo	0	50	0
WVU	287	0	745
University of Kentucky	458	0	0
Praxis	171	387	180
Michigan Tech University	335	0	0
TBD	0	755	94
EG&G	50	0	0
K&M	49	0	0
RTI	2	0	0

Advanced Research and Environmental Technology Funding Recipients
(In Thousands of Dollars)
(Continued)

Recipient	FY95	FY96	FY97
Southern Illinois University	78	513	517
University of Pittsburgh	207	0	0
Arthur D. Little	230	125	253
Babcock & Wilcox	2,212	1,925	400
Carnegie Mellon University	100	280	303
EERC	183	125	270
EPRI	430	1,728	1,091
Gilbert Commonwealth	226	0	0
IGR	0	531	300
Radian	819	406	756
Rust College	200	0	0
ABB	285	50	201
ADA	250	130	150
ATS	278	500	200
Battelle	0	55	0
LSR	258	50	184
Public Service of CO	448	50	298
Weston	0	0	0
Calderon	3,039	0	0
Penelec	0	50	0
University of Hawaii	144	0	0
MIT	0	100	0
PSI	348	0	0
Coal Tech Corp.	100	0	0
Prairie View A&M	57	0	0
USGS	40	0	0
BNL	220	200	0
INEL	205	0	0
ORNL	75	75	0
LBL	530	450	0
NREL	150	0	0
PETC	2,992	3,458	3,050
Burns & Roe	185	125	118
Peddada	159	129	98
International Energy Agency	0	180	180
Total	**18,512**	**14,284**	**9,803**

Q57. For each recipient of Advanced Research and Environmental Technology funds identified in the response to question 56 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A57.

Advanced Research and Environmental Technology Recipient Cost Sharing
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
METC	0	0	0
CTC	43	0	0
UNDEERC	57	57	57
ANL	0	0	0
ERC	0	0	0
ARCTECH	0	0	0
Ames	0	0	0
Dravo	0	117	0
WVU	96	0	248
University of Kentucky	187	0	0
Praxis	198	128	128
Michigan Tech University	112	0	0
TBD	0	128	0
EG&G	0	0	0
K&M	0	0	0
RTI	0	0	0
Southern Illinois University	42	264	267
University of Pittsburgh	49	0	0
Arthur D. Little	51	51	51
Babcock & Wilcox	2,270	2,270	187
Carnegie Mellon University	0	0	0
EERC	61	61	61
EPRI	3,230	4,700	4,200
Gilbert Commonwealth	0	0	0
IGR	0	0	0
Radian	126	126	126
Rust College	12	12	12
ABB	153	153	153
ADA	33	33	33
ATS	0	0	0
Battelle	0	0	0
LSR	49	49	49
Public Service of CO	68	68	68
Weston	100	0	0
Calderon	3,707	3,707	0

Advanced Research and Environmental Technology Recipient Cost Sharing
(In Thousands of Dollars)
(Continued)

Recipient	FY95	FY96	FY97
Penelec	0	75	0
University of Hawaii	0	0	0
MIT	0	0	0
PSI	0	0	0
Coal Tech Corp.	0	0	0
Prairie View A&M	0	0	0
USGS	0	0	0
BNL	0	0	0
INEL	0	0	0
ORNL	0	0	0
LBL	0	0	0
NREL	0	0	0
PETC	0	0	0
Burns & Roe	0	0	0
Peddada	0	0	0
International Energy Agency	0	820	820
Total	**10,644**	**12,819**	**6,460**

Q58. For those Advanced Research and Environmental Technology funding recipients listed in the response to question 56 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A58. The following recipients were awarded funds on a non-competitive basis:

METC–In-house DOE facility with unique capabilities
ANL–National Laboratory with unique capabilities
ERC–Small minority business setaside
Ames–National laboratory with unique capabilities
AFR–Follow-on to competitive award
Mich Tech U.–University grant, unique approach
U. of Pitts.–University grant, unique approach
So. Ill. U.–Unsolicited proposal offering a unique concept
Babcock & Wilcox–Offers a unique facility and considerable cost-sharing
Carnegie Mellon U.–Offers unique capabilities and proprietary computer codes for modeling environmental control technology cost and performance
EPRI–Offers unique facilities and considerable cost-sharing
ATS–Small business with unique capabilities and laboratory facilities for mercury sampling and analysis

Radian–unique capabilities and world-wide recognized expertise
International Energy Agency–Offers unique opportunity or considerable fund leveraging and cost sharing with other countries
BNL–National laboratory with unique capabilities
INEL–National laboratory with unique capabilities
ORNL–National laboratory with unique capabilities
NREL–National laboratory with unique capabilities
PETC–In-House DOE facility with unique capabilities

Q59. On page 45 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997 for Coke Control Emissions, it is stated: "Continue limited level of effort on coke oven emission control technology using prior year funds."

a. What is the amount of "prior year" funds used for each of FY 1995 - FY 1997?

A59a. The coke oven emission control project was fully funded by DOE in FY 1995. Funds in the amount of $3,706,572 were obligated in FY 1995. No additional funding will be provided in either FY 1996 or FY 1997.

b. What was/is the source of these "prior year" funds used for each of FY 1995 - FY 1997?

A59b. The funding source for this project was the FY 1995 appropriation for the Advanced Clean/Efficient Power Systems subprogram.

Q60. On page 46 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1997 for In-House, it is stated: "Continue field monitoring of advanced technology wastes at Clean Coal disposal sites, at surface mine sites and in deep mines for acid drainage abatement using prior year funds, to assure these wastes do not pose a barrier to the deployment of advanced technologies."

Q60a. What is the amount of "prior year funds" to be used in FY 1997, and what is the source of these funds?

A60a. The amount of prior year funds that will be used in FY 1997 to continue field monitoring is $50,000. The source of these funds is the FY 1996 appropriation.

Q60b. What specific sites are being and will be monitored?

A60b. The specific monitoring sites are the Wabash River Coal Gasification Repowering Project, the Milliken DESOX/DENOX Project, and the Custom Coals International Coal Cleaning Project. All three projects are under the Clean Coal Technology Program.

Q61. On page 46 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1997 for In-House, it is stated: "Continue laboratory characterization of advanced technology wastes to assess risks and predict environmental fate using prior year funds."

What is the amount of "prior year funds" to be used in FY 1997, and what is the source of these funds?

A61. The amount of prior year funds to be used in FY 1997 is $50,000. The source of these funds is the FY 1996 appropriations.

Q62. Please describe the "technical and program management support" (page 47 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A62. The technical and program management support activity in the Advanced Research and Environmental Technology program provides systems studies and analyses along with market assessments to assist in the strategic planning, prioritization, and decision-making process for the program. In addition, the technical and management support activities provide logistic and facilitation assistance in the establishment and maintenance of customer liaison and outreach activities in order to provide feedback to the strategic planning process.

Kalina Cycle

Q63. Please provide a listing of the recipients of the $2,000,000 in funding in FY 1996 for Kalina Cycle, including the funding for each recipient.

A63. The sole recipient of the $2,000,000 will be ETEC (Rockwell International) for operation of the Kalina Facility. Of this amount, approximately $40,000 will be spent for completion of construction activities relating to installation of the gas turbine. The other organizations involved with testing at the Kalina Facility, i.e., Exergy, ABB, Alzeta, and Solar Turbines, are not recipients of any of this funding.

Q64. For each recipient of Kalina Cycle funds identified in the response to question 63 above, please provide the level of funding provided by that recipient as cost-sharing for FY 1996.

A64. Although the other organizations involved with testing at the Kalina Facility are not recipients of any of the $2,000,000, they are contributing in kind to its operation. Exergy has provided $1,210,000 for procurement of the gas turbine, Alzeta is providing the Duct Burner which has an estimated value of $200,000 in exchange for test data, Solar Turbines is providing advanced turbine test components, and ABB will provide all necessary material and fund all special testing, estimated at approximately $500,000.

Q65. For those Kalina Cycle funding recipients listed in the response to question 63 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A65. Other than funding to ETEC for expenses associated with operation of the Kalina Facility, there are no funding recipients other than subcontractors required for completion of construction. All subcontracts were competitively bid. The ETEC is a unique site that has all the space and equipment to continue development of the Kalina Cycle.

COAL: ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Coal Utilization Science

Q66. Please provide a listing of the recipients of (i) the $3,036,000 in funding in FY 1995, (ii) the $3,149,000 in FY 1996 funding, and (iii) the requested level of $3,149,000 in FY 1997 for Coal Utilization Science, including the funding for each recipient.

A66.

Coal Utilization Science Funding Recipients
(In Thousands of Dollars)

Recipient	**FY95**	**FY96**	**FY97**
Carnegie Mellon University	90	116	128
Texas A&M	50	0	0
Ohio State University	5	0	0
Sandia National Laboratories	500	400	400
Reaction Eng. International	230	250	264
TBD	0	231	254
Burns & Roe/SAIC (PETC Tech. Support)	0	72	100
PETC	300	300	350
Argonne National Laboratory	244	0	0
Univ. of North Dakota EERC	258	0	0
Advanced Fuel Research	0	100	0
Ames Laboratory	0	138	40
METC	1,256	1,448	1,519
SBIR	0	63	63
Combustion Institute	20	0	0
MIT	10	0	0
National Research Council	42	0	0
Headquarters Technical & Program Support	31	31	31
Total	**3,036**	**3,149**	**3,149**

Q67. For each recipient of Coal Utilization Science funds identified in the response to question 66 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A67.

Coal Utilization Science Funding Recipient
(In Thousands of Dollars)

Recipient	FY95- FY 1997
Carnegie Mellon University	141
Texas A&M	5
Ohio State University	0
Sandia National Laboratories	0
Reaction Eng. International	295
Burns & Roe/SAIC	not funded
Argonne National Laboratory	0
Univ. of North Dakota EERC	0
Advanced Fuels Research	not funded
Ames Laboratory	not funded
Office of Energy Research	0
Combustion Institute	0
MIT	0
Total	**441**

Q68. For those Coal Utilization Science funding recipients listed in the response to question 66 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A68. Non-competitive Awards:

In general, awards based on Unsolicited Proposals may be made after the DOE has reviewed the technical merits of a given proposal and it's fit to the DOE Mission. If this preliminary evaluation is favorable, the proposal is then examined by outside reviewers to determine if the application is meritorious and represents a unique or innovative idea, method or approach that would not be eligible for a current or planned solicitation, and has a high probability for success. All non-competitive Coal Utilization Science actions qualified for award based on the above evaluation criteria.

The specific justification for the recipients identified in question 66 above are as follows:

Recipient/Justification:

Carnegie Mellon University–Unique design of atomizers and burners for coal-liquid slurry.

Texas A&M–Effect of coal particle size on interfacial and teological properties of coal-water slurry by a unique team of exceptional researchers.

Ohio State University–Unique collaborative effort using supercomputer University of North Dakota-Multigas reactor operation, and means to remove hazardous air pollutants developed by novel team of researchers.

Advanced Fuel Research–Measurement and modeling employing unique equipment and modeling capabilities.

Combustion Institute–24th International Combustion Symposium is the only symposium of high caliber that attracts world participation.

MIT–Electric Utilities Program–A unique program at MIT

Q69. Please describe the "technical and program management support" (page 51 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A69. To provide funding for: technical assessments and analyses of Office of Fossil Energy's research program; preparation of briefing materials, program planning and strategic planning documents; comprehensive peer review of FE's advanced research projects; administering DOE's Homer H. Lowry Award; contributing pro rata share of computer/computer support, LAN and budget planning and execution support costs.

Coal Technology Export

Q70. Please provide a listing of the recipients of (i) the $819,000 in funding in FY 1995, (ii) the $819,000 in FY 1996 funding, and (iii) the requested level of $1,054,000 in FY 1997 for Coal Technology Export, including the funding for each recipient.

A70.

Coal Technology Export Funding Recipients
(In Thousands of Dollars)

Recipient	Cost-Shared	Comp. Award	FY95	FY96	FY97
Resource Dynamics	No	Yes	210	99	200
SoBran	No	No	330	422	425
TMS	No	Yes	130	282	200
PCI	No	Yes	0	16	0
LANL	No	N/A	50	0	0
PETC	No	N/A	99	0	229
Total			819	819	1,054

Q71. For each recipient of Coal Technology Export funds identified in the response to question 70 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A71. Each of the recipients listed were not participating in cost-shared projects.

Q72. For those Coal Technology Export funding recipients listed in the response to question 70 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A72. With the exception of SoBran, all recipients listed were either a competitively selected contractor, or was a DOE National Laboratory that received a transfer of funds from our office. The SoBran contract was awarded pursuant to Section 8(A) of the Small Business Act.

Bioprocessing of Coal

Q73. Please provide a listing of the recipients of (i) the $1,928,000 in funding in FY 1995, (ii) the $1,000,000 in FY 1996 funding, and (iii) the requested level of $1,000,000 in FY 1997 for Bioprocessing of Coal, including the funding for each recipient.

A73.

Bioprocessing of Coal Funding Recipients
(In Thousands of Dollars)

Recipient	**FY95**	**FY96**	**FY97**
ORNL	896	600	600
INEL	815	390	390
NREL	198	0	0
Headquarters Program Support	19	10	10
Total	**1,928**	**1,000**	**1,000**

Q74. For each recipient of Bioprocessing of Coal funds identified in the response to question 73 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A74. Since the DOE National Laboratories are Federal laboratories they have no source of funds for cost sharing, nor are they expected to cost share. However, they are encouraged to collaborate with universities and industry where such collaboration is consistent with their program mission assignment and where the non-Federal entity is expending research funding on topics which complement the Laboratories research.

Q75. For those Bioprocessing of Coal funding recipients listed in the response to question 73 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A75. The selection of which Laboratories to utilize is based upon analyses of the core competencies and unique capabilities and facilities of each laboratory, plus the opportunity to leverage Fossil Energy funding through co-location of research at institutions which are conducting relevant basic and applied research funded by other programs which may provide synergies.

Q76. Please describe the "technical and program management support" (page 52 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A76. To provide funding for: technical assessments and analyses of Office of Fossil Energy's research program; preparation of briefing materials, program planning and strategic planning documents; comprehensive peer review of FE's advanced research projects; administering DOE's Homer H. Lowry Award; contributing pro rata share of computer/computer support, LAN and budget planning and execution support costs.

University Coal Research

Q77. Please provide a listing of the recipients of (i) the $4,898,000 in funding in FY 1995, (ii) the $4,001,000 in FY 1996 funding, and (iii) the requested level of $4,001,000 in FY 1997 for University Coal Research, including the funding for each recipient.

A77.

University Coal Research Funding Recipients
(In Thousands of Dollars)

Brown University	200
University of Hawaii	300
Virginia Polytechnic	200
Iowa State University	200
University of Washington	200
University of New Mexico	200
Lehigh University	188
University of Michigan	200
North Carolina AT&T State University	200
Brigham Young University	198
University of Washington	198
University of Rochester	200
Clark Atlanta University	140
Lehigh University	200
University of Utah	200
Auburn University	197
University of Cincinnati	197
Brigham Young University	200
University of Akron	200
Pennsylvania State University	140
University of Kentucky	140
Yale University	200
Massachusetts Institute of Technology	400
Clark Atlanta University	200
Total	4,898

Awards for FY 96 have not been made and are awaiting funds availability. In all fiscal years awards for this program are based on a competitive solicitation in that year.

Q78. For each recipient of University Coal Research funds identified in the response to question 77 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A78.

University Coal Research Funding Recipient Cost Sharing
(In Thousands of Dollars)

Brown University	35
University of Hawaii	18
Virginia Polytechnic	92
Iowa State University	118
University of Washington	15
University of New Mexico	0
Lehigh University	199
Washington University	254
University of Michigan	27
North Carolina AT&T State University	0
Brigham Young University	187
University of Washington	0
University of Rochester	15
Clark Atlanta University	0
Lehigh University	22
University of Utah	0
Auburn University	57
University of Cincinnati	50
Brigham Young University	59
University of Akron	67
Pennsylvania State University	0
University of Kentucky	22
Yale University	25
Massachusetts Institute of Technology	162
Clark Atlanta University	0
Total	1,424

Q79. **For those University Coal Research funding recipients listed in the response to question 77 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.**

A79. All awards were made on a competitive basis.

Q80. **Please describe the "technical and program management support" (page 52 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).**

A80. To provide funding for: technical assessments and analyses of Office of Fossil Energy's research program; preparation of briefing materials, program planning and strategic planning documents; comprehensive peer review of FE's advanced research projects; administering DOE's Homer H. Lowry Award; contributing pro rata share of computer/computer support, LAN and budget planning and execution support costs.

Materials

Q81. **Please provide a listing of the recipients of (i) the $7,750,000 in funding in FY 1995, (ii) the $6,932,000 in FY 1996 funding, and (iii) the requested level of $5,270,000 in FY 1997 for Materials, including the funding for each recipient.**

A81.

Materials Funding Recipients
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
ORNL	2,948	2,958	2,510
ORNL Subcontractors	2,420	1,912	1,374
ANL	795	540	400
INEL	225	225	175
LBNL	100	75	0
PNNL	855	835	600
SNL	325	125	0
Oak Ridge Operations Office	3	3	3
DOE-HQ	79	119	103
SBIR Office	0	140	105
Total	**7,750**	**6,932**	**5,270**

Q82. For each recipient of Materials funds identified in the response to question 81 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A82. The National Laboratories are DOE-owned facilities operated by various universities and private sector companies under contract to the Department. Thus none of the National Laboratories provides cost sharing per se.

In its role as the lead technical management and technical support laboratory, ORNL subcontracts work as shown in the table included with Question 81, above. The industrial subcontractors include cost-sharing of at least 20%; none of the universities provide cost-sharing per se.

Q83. For those Materials funding recipients listed in the response to question 81 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A83. As was noted in the response to question 82, above, the National Laboratories are DOE-owned facilities; funding is noncompetitive and is provided based on Program needs and the respective skills, expertise, and competencies of the National Laboratories. All private sector company subcontracts are awarded on a competitive basis; all of the university subcontracts are noncompetitive awards. Universities are selected based on skills, expertise, facilities, and competencies, i.e., all selected universities must be deemed to be capable of doing quality R&D in the area of interest. However, because of the noncompetitive nature of university subcontracts, prime consideration is given to the use of as many universities as possible. Of course, for any given year, funding limitations restrict the number of university participants, but over several years the AR&TD Materials Program has funded research at twenty-seven universities in eighteen states.

Q84. Please describe the "technical and program management support" (page 53 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A84. To provide funding for: technical assessments and analyses of Office of Fossil Energy's research program; preparation of briefing materials, program planning and strategic planning documents; comprehensive peer review of FE's advanced research projects; administering DOE's Homer H. Lowry Award; contributing pro rata share of computer/computer support, LAN and budget planning and execution support costs.

Components

Q85. Please provide a listing of the recipients of the $818,000 in funding in FY 1995 for Components, including the funding for each recipient.

A85.

Components Funding Recipients
(In Thousands of Dollars)

HQ	9
SBIR/STTR	22
LLNL	59
SNL	250
ANL	135
University of Florida	76
Cornell University	98
University of Missouri	55
Lovelace Institutes	79
N.J. Institute of Technology	35
Total STP	818

Q86. For each recipient of Components funds identified in the response to question 86 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995.

A86.

Components Funding Recipients Cost-Sharing
(In Thousands of Dollars)

University of Missouri	950
N.J. Institute of Technology	30
Total STP	980

Q87. For those Components funding recipients listed in the response to question 86 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A87. University of Missouri ($55K): Uniquely qualified due to participation in the anticipated success of the Coal Log Pipeline (CPL) Consortium under the aegis of the University of Missouri. CPL is a new technology for economically transporting coal, compressed into the form of logs, via underground pipelines utilizing water as the conveying medium, for long distances. Commercial development is expected in 5 years. Other participants are NSF, State of Missouri, industrial participants.

Lovelace Institute ($79K): Lovelace Institute performed the pioneering research on the application of Nuclear Magnetic Resonance Imaging (NMRI) to the flows of concentrated suspensions. This project was an outgrowth of the research by Lovelace on solids transport in the Granular Flow Advanced Research Objective (GFARO), a coordinated multiproject effort in the Components (STP) program. Lovelace had unique capabilities to carry out such NMR work.

N.J. Institute of Technology ($35K): Conducted a set of experiments on a vibrated bed of granular material to study induced convection and/or size segregation. This was an outgrowth of earlier research performed by NJIT in the GFARO program mentioned above.

Environmental Activities

Q88. Please provide a listing of the recipients of (i) the $1,814,000 in funding in FY 1995, (ii) the $2,511,000 in FY 1996 funding, and (iii) the requested level of $2,235,000 in FY 1997 for Environmental Activities, including the funding for each recipient.

Q89. For each recipient of Environmental Activities funds identified in the response to question 88 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

Q90. For those Environmental Activities funding recipients listed in the response to question 90 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A88, A89, A90. Recipients of funding for FY 1995-FY 1997 for Environmental Activities and contract award information are shown in the table below. This is an analysis-oriented activity that helps FE in its internal planning, and provides information that allows FE and the Department to develop sound, cost/benefit based positions on fossil-fuel related environmental issues, including environmental legislative and regulatory proposals. These activities require a high degree of objectivity and are integral to government decision-making processes, and cost-sharing is thus not appropriate.

Environmental Activities Funding Recipients
(In Thousands of Dollars)

FUNDING RECIPIENT	FY95	FY96	FY97	AWARD BASIS/ JUSTIFICATION
ANL	260	150	150	See Note 1
PNNL	150	150	150	See Note 1
LBNL	150	75	75	See Note 1
ICF	577	750	750	Competitive
Resource Dynamics	135	135	135	Competitive
Peddada	100	100	100	Competitive
Technology & Mgmt Services	63	0	0	Competitive
ITSO	79	75	75	Competitive
Compa Industries (NEPA Compl.)	0	200	224	Competitive
PETC (NEPA Compl.)	0	40	0	Internal Transfer
TMS (NEPA Compl.)	300	0	0	Competitive
TBD (air toxics)	0	200	200	Competitive (See Note 2)
TBD (power/ regulatory cost/ benefit)	0	250	250	Competitive (See Note 2)
TBD	0	386	126	Competitive (See Note 2)
Total	**1,814**	**2,511**	**2,235**	

Note 1: While the M&O contractor for DOE National Laboratories is selected on a competitive basis, subsequent tasks are not. National Labs do offer unique capabilities.

Note 2: Some analytical requirements are for initiatives that cannot be anticipated even months in advance, so part of the funding must be held in reserve.

Technical and Economic Analysis

Q91. Please provide a listing of the recipients of (i) the $686,000 in funding in FY 1995, (ii) the $964,000 in FY 1996 funding, and (iii) the requested level of $860,000 in FY 1997 for Technical and Economic Analysis, including the funding for each recipient.

Q92. For each recipient of Technical and Economic Analysis funds identified in the response to question 91 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

Q93. For those Technical and Economic Analysis funding recipients listed in the response to question 92 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A91, A92, A93. Recipients of funding for FY 1995-FY 1997 for Technical and Economic Analysis and contract award information are shown in the table below. This is an analysis-oriented activity that helps FE in its internal planning, and provides information that allows FE and the Department to develop sound, cost/benefit based positions on fossil-fuel related environmental issues, including environmental legislative and regulatory proposals. These activities require a high degree of objectivity and are integral to government decision-making processes, and cost-sharing is thus not appropriate.

Technical and Economic Analysis Funding Recipients
(In Thousands of Dollars)

FUNDING RECIPIENT	FY95	FY96	FY97	AWARD BASIS/ JUSTIFICATION
Stanford University	50	50	50	Grant/Unique capability
ICF Resources	318	250	250	Competitive
DOE/EIA	135	135	75	Internal Transfer
PETC	100	0	0	Internal Transfer
Technology & Mgmt Services	58	0	0	Competitive
Colorado School of Mines	25	25	25	Grant/Unique capability
Resource Dynamics	0	250	250	Competitive
TBD (computer support)	0	50	50	Competitive (See Note 1)
TBD	0	204	160	Competitive (See Note 1)
Total	**686**	**964**	**860**	

Note 1: Some analytical requirements are for initiatives that cannot be anticipated even months in advance, so part of the funding must be held in reserve.

International Program Support

Q94. Please provide a listing of the recipients of (i) the $1,302,000 in funding in FY 1995, (ii) the $1,008,000 in FY 1996 funding, and (iii) the requested level of $1,159,000 in FY 1997 for International Program Support, including the funding for each recipient.

A94.

Coal Technology Export Funding Recipients
(In Thousands of Dollars)

Recipient	Cost-Shared	Comp. Award	FY95	FY96	FY97
IEA Coal Research	Yes	No	900	899	900
Peddada Consultants	No	Yes	260	109	259
TMS	No	Yes	40	0	0
Office of Policy	No	No	40	0	0
ANL	No	No	45	0	0
TBD*	N/A	N/A	17	0	0
Total			1,302	1,008	1,159

*Funds left unplanned in FY 1995 to be used to cover shortfall in FY 1996.

Q95. For each recipient of International Program Support funds identified in the response to question 94 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A95. The International Energy Agency (IEA) is an autonomous agency within the framework of the Organization for Economic Cooperation and Development (OECD). The Agency is the energy forum for 23 industrialized countries. Within the IEA is an Energy Technology Collaboration Programme which provides a cost-effective mechanism, the Implementing Agreement, for member countries to work together on the development of new energy technologies and their introduction into the market. The International Energy Agency Coal Research (IEACR) is a collaborative project involving member countries of the International Energy Agency. Each member of the EEACR provides funding based upon a formula that is derived from that country's coal usage i.e., the more coal a country burns, the more the annual assessment. Total funding for IEACR was approximately 2 million pounds sterling in FY 1995.

Q96. For those International Program Support funding recipients listed in the response to question 94 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A96. The funding for EEA Coal Research is based upon a formula that factors coal usage of member countries, and was agreed upon via an international agreement. The two other non-competitive actions were transfer of funds to other DOE organizations.

Instrumentation and Diagnosis

Q97. Please provide a listing of the recipients of the $964,000 in funding in FY 1995 for Instrumentation and Diagnosis, including the funding for each recipient.

A97.

Instrumentation and Diagnosis Funding Recipients
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
Ames Laboratory	354	0	0
METC	590	0	0
MIT	10	0	0
Headquarters Program Support	10	0	0
Total	**964**	**0**	**0**

Q98. For each recipient of Instrumentation and Diagnosis funds identified in the response to question 97 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995.

A98. There is no cost-sharing by any of the funding recipients.

Q99. For those Instrumentation and Diagnosis funding recipients listed in the response to question 97 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A99. The selection of which Laboratories to utilize is based upon analyses of the core competencies and unique capabilities and facilities of each laboratory, plus the opportunity to leverage Fossil Energy funding through co-location of research at institutions which are conducting relevant basic and applied research funded by other programs which may provide synergies.

MIT faculty provided unique one-day seminar to office personnel.

University/National Laboratory Coal Research HBCUs, Education and Training

Q100. Please provide a listing of the recipients of (i) the $946,000 in funding in FY 1995, (ii) the $969,000 in FY 1996 funding, and (iii) the requested level of $1,140,000 in FY 1997 for University/National Laboratory Coal Research HBCUs, Education and Training, including the funding for each recipient.

A100(i). In FY 1995, the recipients of the $946,000 in funding for the HBCU Program were the following:

Prairie View A&M University, Prairie View, Tex., received a $137,000 grant for a 15 month research project to improve today's technology for gasifying coal. Converting coal into a combustible gas offers an extremely clean, efficient approach for power generation, and many utilities have included coal gasification power plants in their construction plans. The Prairie View A&M research, headed by Dr. Daniel Mei, focuses on innovative ways to remove coal ash using "pulse detonation technology." The project could reveal a new type of environmental control technology for the cleaner use of coal in the 21st century. Prairie View A&M teamed with Lockheed Fort Worth Company.

Hampton University, Hampton, Va., received a $142,000 grant for a two-year research project to study chemical compounds that can absorb sulfur pollutants from the hot gases of advanced coal-based power plants. "Hot gas desulfurization" is a key technology for improving the performance of coal gasification power plants. These power plants are expected to make up a growing portion of the next generation of baseload power stations in the U.S. and overseas. The research contact is Dr. K. Jothimurugesan. Hampton teamed with Research Triangle Institute and United Catalysts Inc.

Clark Atlanta University, Atlanta, Ga., received two grants, both in the area of advanced petroleum refining research. One, for $200,000 in Federal funds, supports a five-year research project on advanced concepts for extracting useful hydrocarbons from the thick "resid" oil that is often left unprocessed by conventional refining technology. Dr. Conrad Ingram heads the research team. The other, for $10,000, is a one-year exploratory grant to study chemical impurities in crude oil that can damage the catalysts used in refining processes. Dr. Xiu R. Bu is the lead researcher. In the larger project, Clark Atlanta teamed with Texaco, Port Authur, Tex.

Morgan State University, Baltimore, Md., received a $200,000 grant for a three-year research project to develop instrumentation and advanced computer models that will help improve future electric power plant designs. The

University studies the way heat is transferred in a "circulating fluidized bed" coal combustor, one of the most advanced, cleanest-burning concepts now available for using coal to generate electricity. Understanding the heat transfer characteristics of these combustors will help improve their designs and future performance. Dr. Seong W. Lee leads the research team. Morgan State teamed with Donlee Technologies of York, Pa., and Combustion Systems Inc. of Silver Spring, Md.

Fort Valley State College, Fort Valley, Ga., received a $140,000 grant to study the use of advanced geostatistical techniques in defining the characteristics of an oil. Today's oil companies, especially the smaller independent producers who make up a growing share of the U.S. industry, are recognizing that a better understanding of the geologic properties of an oil reservoir can reveal opportunities for increased oil production. The 14-month Fort Valley State project, led by Dr. Issac J. Crumbly, helps give these operators better "tools" for obtaining this knowledge and boosting domestic oil production. Fort Valley State teamed with Applied Research Associates.

Southern University, Baton Rouge, La., received a $107,000 grant for a two-year research project to improve the technology of "solid oxide" fuel cells. Fuel cells are a new way to generate electricity from fossil fuels. Because they rely on an electrochemical reaction (like a battery) rather than combustion, they are extremely clean power sources. Southern's project concentrates on one of the most advanced fuel cells concepts-an all solid-state device that can operate a high temperatures and generate electricity very efficiently. The research contact is Dr. Bobba Rambabu. Southern teamed with Motorola Energy Systems.

TOTAL	$936,000
	$10,000 (Technical and Program Management Support)
GRAND TOTAL	$946,000

A100ii. The FY 1996 HBCU Solicitation process is on going. Selection is anticipated in the August-September 1996 period.

A100iii. In FY 1997, the recipients of the requested level of $1, 140,000 funding for HBCUs and other Minority Institutions will be decided through the Competitive Solicitation Process beginning in February 1997. The solicitation will be sent to at least 117 HBCUs and 50 or more other Minority Institutions.

Q101. For each recipient of University/National Laboratory Coal Research HBCUs, Education and Training funds identified in the response to question 100 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A101. The level of funding provided by the recipient as cost-sharing for FY 1995 were as follows:

•	Clark Atlanta University Awardee Share	$3,200
	Total Project Value	$13,200
•	Clark Atlanta University Awardee Share	$14,300
	Total Project Value	$214,300

The level of funding by the recipients as cost-sharing for FY 1996 is pending. The HBCU solicitation is in progress and no awards have been made. The projected date of awards is August or September 1996. The FY 1997 awardee share cannot be determined.

Q102. For those University/National Laboratory Coal Research HBCUs, Education and Training funding recipients listed in the response to question 100 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A102. The HBCUs identified in question 100 above all competed in the annual Office of Fossil Energy solicitation. No funds were awarded on a non-competitive basis.

Q103. Please describe the "technical and program management support" (page 56 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A103. The "technical and program management support" consists of visits to HBCUs and other Minority Institutions to help in upgrading the technical capabilities of the research facility at the site university, consultation with the principal investigator on existing grants, and promote cooperation between academia, industry and government to provide a forum for technology transfer.

NATURAL GAS RESEARCH

Exploration and Production

Q104. Please provide a listing of the recipients of (i) the $18,373,000 in funding in FY 1995, (ii) the $14,162,000 in FY 1996 funding, and (iii) the requested level of $15,000,000 in FY 1997 for Exploration and Production, including the funding for each recipient.

A104. See Table 1, columns A, B, C and D attached.

Q105. For each recipient of Exploration and Production funds identified in the response to question 104 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A105. See Table 1, column E attached.

Q106. For those Exploration and Production funding recipients listed in the response to question 104 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A106. See Table 1, column F attached.

Table 1. Exploration and Production Funding Recipients
(In Thousands of Dollars)

AWARDEE	FY95 ADJUST APPROP	FY96 CONF	FY97 CONG'L REQ	PERCENT COST SHARE	NON-COMPETITIVE AWARDS
(Column A)	(Column B)	(Column C)	(Column D)	(Column E)	(Column F)
GEOPHYSICAL	173	0	0	0	
UNIV. TEXAS BUR. ECO. GEOG.	800	800	690	60	unsol. proposal, unique capability
COLLEGE OF W. VIRGINIA	400	0	0	5	
K&M	130	200	173	0	
LBNL	353	150	432	0	
ICF REOURCES	436	400	312	0	
ENERGY & ENVIRON. ANALY.	750	600	508	3	
SMITH INTERNATIONAL	0	700	528	32	unsol. proposal, unique capability
BELDEN & BLAKE	110	0	0	36	

AWARDEE	FY95 ADJUST APPROP	FY96 CONF	FY97 CONG'L REQ	PERCENT COST SHARE	NON-COMPETITIVE AWARDS
SANDIA NATIONAL LAB	250	132	192	N/A	
UNIV. OF OKLAHOMA	500	800	719	46	unique capability, and no similar activity currently planned by industry
DOI MINERALS MGMT SERVICE	195	0	0	17	
CER	1,621	67	0	51	
ADVANCED RESOURCES INTL.	450	920	470	6	
MAURER ENGINERING	245	280	66	15	no similar activity currently planned by industry; cost-shared
U. S. GEOL. SURVEY	350	350	302	0	
UNION PACIFIC RESOURCES	1,705	1,500	2,110	30	
SPERRY-SUN	289	700	256	30	
MARINE BRD	25	25	24	0	
MAURER ENGINERING	50	0	0	44	
GEOSCI ELEC	90	75	0	34	
MAURER	300	200	62	18	
FLOW DRILL CORP.	305	280	0	51	
PCS	499	350	364	0	
COLEMAN RESEARCH	1,184	975	530	0	
BLACK WARRIOR	50	0	0	6	
NW FUEL DEVELOPMENT	50	0	200	19	
JIM WALTER CORP.	100	0	200	17	
NOUMENON	50	0	200	8	
WEST VIRGINIA UNIVERSITY	50	0	200	24	
UNITED ENERGY	50	0	0	0	
BIOENGINEERING	50	0	0	4	
ERC	50	0	200	18	
WENDT	50	0	0	12	
TBD	0	2,474	4,534	N/A	
UNIV. OF ALABAMA	5	0	0	0	
METC	1,547	950	643	N/A	
BPO	0	700	831	N/A	
*LQGU/Processing	1,369	0	0		Moved to Gas Processing in FY96
HQ	3,742	534	254	N/A	
TOTAL D&S AWARDS	**18,373**	**14,162**	**15,000**		

Q107. Please describe the "technical and program management support" (page 62 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A107. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Delivery and Storage

Q108. Please provide a listing of the recipients of (i) the $1,046,000 in funding in FY 1995, (ii) the $1,071,000 in FY 1996 funding, and (iii) the requested level of $1,000,000 in FY 1997 for Delivery and Storage, including the funding for each recipient.

A108. See Table 2, Columns A, B, C and D below.

Q109. For each recipient of Delivery and Storage funds identified in the response to question 108 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A109. See Table 2, Column E below.

Q110. For those Delivery and Storage funding recipients listed in the response to question 108 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A110. See Table 2, Column F below. There were no non-competitive awards made in the Delivery and Storage program.

Table 2. Delivery and Storage Funding Recipients
(In Thousands of Dollars)

AWARDEE (Column A)	FY95 ADJUST APPROP (Column B)	FY96 CONF (Column C)	FY97 CONG'L REQ (Column D)	PERCENT COST SHARE (Column E)	NON-COMPETITIVE AWARDS (Column F)
METC	100	100	100	N/A	
K&M	0	50	75	0	
ADVANCED RESOURCES INT	689	350	135	0	
UNITED ENERGY DEV. CONS.	117	0	0	N/A	
ICF	79	160	0	N/A	
HALIBURTON	0	0	360	33	

TBD	0	400	320	N/A	
HQ	61	11	10	N/A	
TOTAL D&S AWARDS	1,046	1,071	1,000	33	

Q111. Please describe the "technical and program management support" (page 62 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A111. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Advanced Turbine Systems

Q112. Please describe the Advanced Turbine Systems work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A112. The Advanced Turbine Systems (ATS) Program is a comprehensive program to develop highly efficient gas turbine systems with superior environmental performance. The program objectives were developed in cooperation with turbine users, fuel suppliers, turbine manufacturers, and supporting research and development organizations through two public workshops held in 1991 and 1992. A plan outlining the program objectives, schedule and funding requirements is documented in "Comprehensive Program Plan for Advanced Turbine Systems, Report to Congress" (July 1993, DOE/FE-0279).

The Fossil Energy portion of the ATS program is divided into two major components: (1) the Natural Gas Initiative which supports major turbine manufacturers to develop and demonstrate an ATS; and (2) the Ultra-High Efficiency Gas Turbine Program which supports technology based research (e.g. Industry/University Research Consortium) to support the development and demonstration of an ATS system. Initially six major turbine manufacturers (Allison Engine Company, Asea Brown Boveri, General Electric, Turbo Power & Marine, Solar Turbines and Westinghouse Electric Corporation) participated in the ATS Program. A competitive down-selection process, achieved by a series of two competitive solicitations, has reduced the number of major turbine manufacturers to four (Allison Engine Company, General Electric, Solar Turbines and Westinghouse Electric Corporation). General Electric and Westinghouse Electric Corporation, with funding from DOE's Office of Fossil Energy, are developing utility scale ATS systems (greater than 400 megawatts) while Allison Engine Company and Solar Turbines, with funding from DOE's Office Energy

Efficiency and Renewable Energy, are developing industrial scale ATS's (nominally 10 megawatts). Turbine manufacturers have undertaken intensive cost-shared large-scale testing and development programs to meet the objectives of demonstrating an ATS in the year 2000.

The cost of the ATS program funded by DOE Fossil Energy through fiscal year 1995 was $68.9 million. Cost sharing, over this same period, provided by the developers was $14.3 million. The total cost of the ATS program from FY 1996 to FY 2000 is estimated to be approximately $520 million. The DOE Office of Energy Efficiency and Renewable Energy portion of this cost is approximately $128 million. Turbine manufacturers and their development teams will provide the remaining $167 million.

Upon completion of the ATS program, U.S. turbine manufacturers will possess the most efficient cost effective gas turbine technology in the world. These technologies will be marketed on domestic and foreign markets.

The products of the ATS program will promote the efficient and environmentally responsible use of natural gas.

Q113. Please provide a listing of the recipients of (i) the $36,983,000 in funding in FY 1995, (ii) the $36,770,000 in FY 1996 funding, and (iii) the requested level of $31,600,000 in FY 1997 for Advanced Turbine Systems, including the funding for each recipient.

Advanced Turbine Systems Funding Recipients
(In Millions of Dollars)

Recipient	FY95	FY96	FY97
Major Developers			
Allison Engine Co.	3.8	----	----
ABB	1.6	0.4	1.8
General Electric	11.0	15.0	----
Solar	----	----	----
General Electric/Westinghouse	----	----	21.3
Westinghouse	8.8	11.1	----
Subtotal	*25.2*	*26.5*	*23.1*
Technology Base Research			
South Carolina Energy R&D Center	4.8	4.3	4.0
Oak Ridge National Lab.	1.0	1.4	1.9
METC	2.5	2.8	2.1
Alternate Fuels (AFR/BYU, GE, Westinghouse, Hague)	3.1	----	----
Technology Research (TBD)	----	1.4	----

Recipient	FY95	FY96	FY97
Other (gen. reductions, program mgmt., etc.)	0.3	0.3	0.3
Subtotal	*11.7*	*102*	*8.3*
Total	**36.9**	**36.7**	**31.4**

Q114. For each recipient of Advanced Turbine Systems funds identified in the response to question 113 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

Advanced Turbine Systems Funding Recipient Cost-Sharing
(In Millions of Dollars)

Recipient	FY95	FY96	FY97
Major Developers			
Allison Engine Co.	1.3	----	----
ABB	0.5	0.1	0.6
General Electric	7.2	36.9	----
Solar	----	----	----
General Electric/Westinghouse	----	----	21.0[1]
Westinghouse	3.7	7.4	----
Total	**12.7**	**44.4**	**21.6**

Notes: 1. Budgetary estimate, uncertainty due to significant shortfall between DOE budget and developer needs.

Q115. For those Advanced Turbine Systems funding recipients listed in the response to question 113 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A115. The South Carolina R&D Center (SCERDC) was awarded non-competitively through acceptance of an unsolicited proposal. SCERDC demonstrated unique knowledge and expertise in gas turbine research as demonstrated by the Advanced Gas Turbine Workshops sponsored by Clemson University in 1991 and 1992. These workshops formed the initial basis to formulate the ATS program.

Oak Ridge National Laboratory (ORNL) has been funded on a non-competitive basis to perform materials research. The justification to support ORNL is base upon their unique expertise in materials science.

Q116. Given the strong market potential and economic incentives for advanced turbine systems, please document why such systems will not be developed in the absence of DOE funding.

A116. Without DOE funding, we believe gas turbine manufactures would continue making upgrades in performance and incremental improvements that produce modest gains in turbine efficiency and emissions reductions but not the high-risk, "Leap-Frog" advances in the efficiency and environmental performance of these systems. However, we do recognize the U.S. manufacturers either have their own allied high technology turbine businesses such as aircraft engines and ship propulsion systems, or have technology partnerships with other firms that give them access to turbine R&D resources that contribute toward advancement of power systems technology. Leveraging investment of the federal government and the private sector to share the risk of developing the ATS enables the domestic gas turbine industry to achieve ATS goals and maintain U.S. global leadership in the gas turbine marketplace. U.S. leadership will enhance exports of domestic products that will support high wage U.S. jobs. This position was documented in a series of workshops held at Clemson University in 1991-1992 to define the goals of the ATS program.

Q117. Please describe the "technical and program management support" (page 63 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A117. The technical and program management support activity in the Advanced Turbine Systems Program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization, and decision-making process for the program. The support activities also provide program information and technology assessments of international competitors to assess their progress, degree of emphasis, and program direction in the gas turbine area. In addition, the technical and management support activities provide logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the Advanced Turbine Systems strategy and planning.

Utilization

Q118. Please provide a listing of the recipients of (i) the $3,185,000 in funding in FY 1995, (ii) the $4,774,000 in FY 1996 funding, and (iii) the requested level of $4,841,000 in FY 1997 for Utilization, including the funding for each recipient.

A118. See Table 3, columns A, B, C and D attached.

Q119. For each recipient of Utilization funds identified in the response to question 118 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A119. See Table 3, column E attached.

Q120. For those Utilization funding recipients listed in the response to question 118 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A120. See Table 3, column F attached.

Table 3. Utilization (Gas Processing) Funding Recipients
(In Thousands of Dollars)

AWARDEE (COLUMN A)	FY95 ADJUST APPROP (COLUMN B)	FY96 CONF (COLUMN C)	FY97 CONG'L REQ (COLUMN D)	PERCENT COST SHARE (COLUMN E)	NON-COMPETITIVE AWARDS (COLUMN F)
MEMB TECH & RESEARCH	0	100	100	0	
UNIV. OF COLORADO	100	100	0	0	unsolicited proposal; performer possesses unique capability
K&M ENGINEERING	57	54	0	0	
SYRACUSE UNIV.	151	150	150	0	unsolicited proposal; performer possesses unique capability & facilities
SANDIA NATIONAL LAB.	125	125	100	N/A	
INSTITUTE OF GAS TECHNOLOGY	150	0	100	52	no similar activity currently planned by industry; unique Federal contribution; GRI coordinated
LBNL	173	100	100	N/A	
INEL	290	400	400	N/A	
TEXAS A&M UNIV.	75	100	100	0	no similar activity currently planned by industry; unique Federal contribution; GRI coordinated
LANL	240	450	400	N/A	
ENERGY INTERNATIONAL	136	132	0	0	performer is only responsible source for constrained application
MEMB TECH & RESEARCH	0	231	161	0	
DEPT OF THE INTERIOR	22	0	0	0	
INST OF GAS TECHNOLOGY	217	232	156	0	
SRI INTERNATIONAL	245	232	156	0	
LLNL	150	0	0	N/A	
GAS TECHNOLOGY INFO.	468	320	320	77	no similar activity currently planned by industry; unique Federal contribution
METC	210	300	200	N/A	
TBD	0	0	250	N/A	

AWARDEE (COLUMN A)	FY95 ADJUST APPROP (COLUMN B)	FY96 CONF (COLUMN C)	FY97 CONG'L REQ (COLUMN D)	PERCENT COST SHARE (COLUMN E)	NON-COMPETITIVE AWARDS (COLUMN F)
HQ	43	48	48	N/A	
Subtotal	2,852				
counted in E&P awards	-1,369				
Subtotal METC (gas processing)	1,483	3,074	2,741		
PETC	0	200	200	N/A	
SANDIA NATIONAL LAB.	225	0	0	N/A	
ARGONNE NATIONAL LAB.	313	325	300	N/A	
DOW CORNING	100	268	900	71	performer possesses unique capability
ALTAMIRA INTR.	97	0	0	0	
COLO. SCHOOL OF MINES	54	60	0	0	
UNIV. OF DELAWARE	51	87	0	5	
INST. OF GAS TECHNOLOGY	164	212	150	15	
MIT	98	89	0	0	
SRI INTERNATIONAL	100	40	0	1	
WORCESTER POLY.	200	31	0	8	
INT'L CONSORTIUM NGC	100	50	50	92	
AMOCO/AIR PRODUCTS	0	338	500	54	unsolicited proposal; performer possesses unique capabilities
Subtotal PETC (gas processing)	1,702	1,700	2,100		
TOTAL, UTILIZATION	3,185	4,774	4,841		

Q121. On page 63 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1996 - FY 1997 for Utilization, it is stated: "Continue support of an international center for information on natural gas technologies."

Please describe this center.

A121. The International Center for Gas Technology Information (ICGTI) is the natural gas technology information center of the International Energy Agency (IEA). The IEA, founded in 1974, is the energy forum for 23 industrialized countries and assists member countries to set up collaborative projects for research, development, and demonstrations of energy-related technologies. The current ICGTI membership includes Canada, Denmark, Japan, Portugal, Russia, Spain and the United States, and one corporate sponsor Columbia Gas System of the United States.

The International Center for Gas Technology Information was established as a permanent IEA program with the signing of an Implementing Agreement on April 4, 1995. The charter signers of the agreement establishing the Center represent more than 50 percent of the 74.5 trillion cubic feet (Tcf) of the world's natural gas production and consumption. The worldwide consumption of natural gas is projected to increase by 47 percent between 1990 and 2010 while the projected increase in overall energy demand is only 36 percent for the same time period. Gas Technology Information, Inc., located in Washington, D.C. and the Danish Gas Technology Center, located in Horsholmn, Denmark, operate ICGTI on behalf of its members and IEA.

The primary mission of the ICGTI is to increase the rate of technological innovation and commercialization of gas-related technologies for the global gas industry by providing an international forum for natural gas technology information exchange and collaboration. The central focus of the ICGTI's mission is developing the "GTI On-Line", a gas technology information exchange system using the World Wide Web on the Internet. The "GTI On-Line" system is an Internet-based electronic information exchange system available to the global energy industry. The "GTI On-Line" provides access to technology information exchange, technology analysis, and technology transfer on natural gas exploration and production, transmission, natural gas storage, distribution, residential, and commercial end-use technologies. In addition, natural gas vehicles and environmental technologies are also featured.

Q122. Please describe the "technical and program management support" (pages 63 and 64 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A122. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Environmental Research/Regulatory Impact Analysis

Q123. Please provide a listing of the recipients of (i) the $2,930,000 in funding in FY 1995, (ii) the $2,945,000 in FY 1996 funding, and (iii) the requested level of $4,650,000 in FY 1997 for Environmental Research/Regulatory Impact Analysis, including the funding for each recipient.

Q124. For each recipient of Environmental Research/Regulatory Impact Analysis funds identified in the response to question 123 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A123. & A124. The list of recipients of the $2,930,000 funding in FY 1995, the $2,945,000 funding in FY 1996, and the $4,650,000 funding in FY 1997 for Environmental Research/ Regulatory Impact Analysis are listed below. Also listed is the level of funding provided by the recipient as cost-sharing for each of FY 1995-1997.

Environmental Research/Regulatory Impact Analysis Funding Recipients and Cost-Sharing
(In Thousands of Dollars)

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
GE-01	ICF	323	150	150	
	TBD-Leg/reg anal, metrics	202	341	160	
	TBD-CONT. NORM.	0	50	50	
	TOTAL	525	525	360	
GE-02	MVP	0	500	0	63
	SE Louisiana Univ.	0	50	0	41
	TBD - produced water	400	0	425	50
	LAB/TBD-ADVANCED TECH	0	0	1,980	50
	SNL	150	0	153	
	TOTAL	550	550	2,558	
GE-03	IOGCC	150	150	160	
	TOTAL	150	150	160	
GE-04	ANL	200	500	300	
	BPF	825	1,025	1,025	
	TBD-CONT. NORMAL ACTIVITIES	500	0	200	
	TOTAL	1,525	1,525	1,525	
	SNL	150	150	0	50
	Tech and Program Management	30	29	47	
GRAND TOTAL		2,930	2,945	4,650	

Q125. For those Environmental Research/Regulatory Impact Analysis funding recipients listed in the response to question 123 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A125. The recipients that were awarded on a non-competitive basis and the justification for that award are listed below:

GE-01: Interstate Oil and Gas Compact Commission–offers a unique opportunity in that it will provide needed enhancements to the Toxic Release Inventory and assure that the concerns of the states and DOE are properly and accurately presented in all meetings. There is no other alternative since the Interstate Oil and Gas Compact Commission is the logical partner to assist the EPA with this project.

GE-02: Wetlands Restoration Lab Southeastern Louisiana University–Southeastern Louisiana University is unique in the United States in that it houses a mesocosm facility designed for projects involving wetlands. This project is designed for the purpose of conducting elemental analysis of restored drill site cuttings used in hydrologic regimes simulated by the mesocosm facility unique to the Wetlands Restoration Lab at the Southeastern Louisiana University.

Q126. Please describe the "technical and program management support" (page 65 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A126. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Fuel Cells

Advanced Research

Q127. Please provide a listing of the recipients of (i) the $1,430,000 in funding in FY 1995, (ii) the $1,317,000 in FY 1996 funding, and (iii) the requested level of $1,218,000 in FY 1997 for Advanced Research, including the funding for each recipient.

A127.

Advanced Research Funding Recipients
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
Argonne National Lab	480	550	550
Pacific NW Lab	350	300	300
Westinghouse	149	74	0
U of Missouri	181	200	200
Energy Research Corp.	127	0	0
M-C Power Corp.	45	0	0
NW Indust. Res. Lab	0	180	156
METC	83	0	0
Tech & Mgmt Support (Parsons)	15	13	12
Total	1,430	1,317	1,218

Q128. For each recipient of Advanced Research funds identified in the response to question 127 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A128. No contract cost-sharing is being provided by the recipients listed in Question 127.

Q129. For those Advanced Research funding recipients listed in the response to question 127 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A129. The University of Missouri award was non-competitive and was the result of an unsolicited application for research. Unsolicited applications for assistance meet stringent criteria for selection in accordance with DOE Assistance Regulation 10 CFR 600.14. Unsolicited applications for research are in fact competing for very limited advanced research funds. Only the best are chosen. The National Laboratories are DOE owned facilities; funding is noncompetitive and is provided based on Program needs and the respective skills, expertise, and competencies of the National Laboratories.

Q130. Please describe the "technical and program management support" (pages 67 and 68 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A130. The technical and program management support activity in the fuel cells Advanced Research program provides materials studies and analyses to assist in the strategic planning, prioritization and decision-making process for the program. The support activities also provide program information and technology assessments of international competitors to assess their progress, degree of emphasis and program direction in the Advanced Research area. In addition, the technical and management support activities provide logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the fuel cells Advanced Research program strategy and planning.

Molten Carbonate Systems

Q131. Please describe the Molten Carbonate Fuel Cell Systems work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A131. Description: The goal of the Molten Carbonate Fuel Cell Program is to develop and scale up molten carbonate technology and to foster market readiness of power plant systems by 2000. Current work consists of two cost-shared field tests of integrated power plants and cost-shared efforts for product improvement and cost reduction of systems to achieve market readiness.

Progress: Progress by developers has been excellent. Fuel Cell stacks have been scaled up to commercial size. Field test efforts are scheduled to begin system testing in 1996. Developers are incorporating system improvements and cost reduction which are projected to provide market readiness by 2000.

Cost to date: DOE cost of the Molten Carbonate Fuel Cell Program from FY 1977 through FY 1996 is $306 million.

Completion: Under funding levels in negotiated cooperative agreements, completion of work is expected to occur in 1999. Cost of completion beyond FY 96 is about $94 million over 3 years. Expected results at completion are developed systems suitable for market entry by 2000.

Funding: Funding ($million) of two developers, Energy Research Corporation (ERC) and M-C Power through to completion of work is shown below:

	Contract Values (FY 95 - FY 99)		DOE cost to complete (beyond 96)
	DOE	Private Sector	
Field Tests			
ERC	28.3	22.8	0
M-C Power	14.1	14.1	0
Product Improvement and Cost Reduction			
ERC	78.1	39.5	47.5
M-C Power	70.6	33.3	46.8

Q132. Please provide a listing of the recipients of (i) the $29,434,000 in funding in FY 1995, (ii) the $38,067,000 in FY 1996 funding, and (iii) the requested level of $32,899,000 in FY 1997 for Molten Carbonate Systems, including the funding for each recipient.

A132. A listing of the recipients of funding for the Molten Carbonate Fuel Cell Program for FY 1995, FY 1996, and FY 1997 and the amounts ($000) for each recipient is contained in the following table:

Molten Carbonate Systems Funding Recipients
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
ERC	13,599	18,227	15,790
M-C Power	14,683	18,227	15,790
ERC	200	0	250
Arthur D. Little	200	200	200
BIRL (N.W. Ind. Res. Lab)	0	532	340
Argonne National Lab	356	400	100
METC	102	100	100
Tech. & Mgmt Support (Parsons)	294	381	329
Total	**29,434**	**38,067**	**32,899**

Q133. For each recipient of Molten Carbonate Systems funds identified in the response to question 132 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A133. Private sector cost sharing amounts ($000) are estimated based on prorated cooperative agreement cost-sharing amounts and are contained in the following table:

Molten Carbonate Systems Funding Recipient Cost Sharing
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
ERC	15,900	10,253	8,880
M-C Power	400	8,617	7,470
Total	**16,300**	**18,870**	**16,350**

Q134. For those Molten Carbonate Systems funding recipients listed in the response to question 132 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A134. All private sector recipients identified in response 132 above (excluding the National Laboratories) were awarded contracts through competitive procurement processes. Argonne is a DOE National Lab; therefore, funding is non-competitive and is based on Program needs and the respective skills, expertise, and competencies of the National Laboratories.

Q135. Please describe the "technical and program management support" (page 68 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A135. The technical and program management support activity in the molten carbonate fuel cells program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization and decision-making process for the program. The support activities also provide program information and technology assessments of international competitors to assess their progress, degree of emphasis and program direction in the molten carbonate area. In addition, the technical and management support activities provides logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the molten carbonate fuel cells program strategy and planning.

Advanced Concepts

Q136. Please describe the Advanced Concepts Fuel Cell work, its progress and cost to date, expected date and cost of completion, and expected results at completion. Also, please include both DOE and private sector funding.

A136. Description: The goal of the Advanced Concepts (solid oxide) Fuel Cell Program is to develop and scale up solid oxide technology and to foster market readiness of power plant systems just after the turn of the century. Current work consists of cost-shared scale-up and field test of an integrated power plant system. The remaining phase (to start in FY 97) involves product improvement and cost reduction to develop a market ready system.

Progress: Progress by the developer has been excellent. The physical dimensions of fuel cells bundles have been scaled-up to what the contractor believes is the commercial size. Life tests on cells have shown potential for long term operation (test cells operating for over 7 years). Small 25 kilowatt generators have been successfully operated on a variety of fuels. Field testing of a 100 kilowatt system is scheduled to begin under a private sector agreement in 1997. The remaining phase (to start in FY 97) is to identify and incorporate system improvements and cost reductions to achieve market readiness.

Cost to date: DOE cost of the Advanced Concepts (solid oxide) Fuel Cell Program from FY 1977 through FY 1996 is $160 million.

Completion: Under funding levels in negotiated cooperative agreements, completion of work is expected to occur by the end of 2000. Cost of completing planned work beyond FY 96 is currently under negotiation. Expected results at completion are developed systems suitable for market entry just after the year 2000.

Funding: The current effort by the developer, Westinghouse, is to be concluded in early FY 1997 with FY 1996 funding of $12.9 million. The concluding phase of the program is currently being negotiated. Funding through to completion of this work is also under negotiation.

Q137. Please provide a listing of the recipients of (i) the $16,091,000 in funding in FY 1995, (ii) the $13,080,000 in FY 1996 funding, and (iii) the requested level of $12,500,000 in FY 1997 for Advanced Concepts, including the funding for each recipient.

A137. A list of the recipients of funding for Advanced Concepts (Solid Oxide Fuel Cells) Program for FY 1995, FY 1996, and FY 1997 and the amounts ($000) for each recipient is shown in the table below:

Advanced Concepts (Solid Oxide Fuel Cells) Funding Recipients
(In Thousands of Dollars)

Recipient	**FY95**	**FY96**	**FY97**
Westinghouse	15,910	12,949	12,375
Tech & Mgmt Support (Parsons)	181	131	125
Total	**16,091**	**13,080**	**12,500**

Q138. For each recipient of Advanced Concepts funds identified in the response to question 137 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A138. Private sector cost sharing amounts ($000) are estimated based on prorated cooperative agreement cost-sharing amounts and are contained in the following table:

Advanced Concepts (Solid Oxide Fuel Cells) Funding Recipient Cost-Sharing
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
Westinghouse	22,800	18,600	12,400

Q139. For those Advanced Concepts recipients listed in the response to question 137 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A139. All private sector recipients identified in response 137 above were awarded contracts through competitive procurement processes.

Q140. Please describe the "technical and program management support" (page 68 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A140. The technical and program management support activity in the advanced concepts (solid oxide) fuel cells program provides systems studies and analyses and market assessments to assist in the strategic planning, prioritization and decision-making process for the program. The support activities also provide program information and technology assessments of international competitors to assess their progress, degree of emphasis and program direction in the advanced concepts (solid oxide) area. In addition, the technical and management support activities provides logistical and facilitation assistance in establishing and maintaining stakeholder liaison and customer outreach which provide important feedback on the advanced concepts (solid oxide) fuel cells program strategy and planning.

OIL TECHNOLOGY

Exploration and Production Supporting Research

Q141. Please provide a listing of the recipients of (i) the $35,432,000 in funding in FY 1995, (ii) the $33,483,000 in FY 1996 funding, and (iii) the requested level of $34,023,000 in FY 1997 for Exploration and Production Supporting Research, including the funding for each recipient.

Q142. For each recipient of Exploration and Production Supporting Researcb funds identified in the response to question 141 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A141. & A. 142. The list of recipients of the $35,432,000 funding in FY 1995, the $33,483,000 funding in FY 1996, and the $34,023,000 funding in FY 1997 for Exploration and Production Supporting Research are listed below. Also included is the level of funding provided by the recipient as cost-sharing for each of FY 1995-FY 1997.

Exploration and Production Supporting Research Funding Recipients and Cost-Sharing
(In Thousands of Dollars)

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
SR-01	COMPUTER MODEL GROUP	30	35	35	99
	ICF/TMS	895	800	500	
	M&O	4,249	4,132	3,426	
	METC/MMS	250	250	0	
	UNIV. OF HOUSTON	5	0	0	95
	UNIV. OF KANSAS	250	0	0	9

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
	USGS	30	30	30	
	TOTAL	5,709	5,247	3,991	
SR-03	M&O	900	950	600	
	TOTAL	900	950	600	
SR-04	COLORADO SCHOOL OF MINES	2	0	0	
	INEL	327	350	250	50
	LBL	350	350	250	
	LANL	28	0	0	
	M&O	6,637	5,985	3,634	18
	PRDA-ADVANCED RECOVERY	0	0	1,715	20
	AUPRI/USC	828	835	644	20
	RERI	15	0	0	19
	UNIV. OF HOUSTON	2	0	0	95
	UNIV. OF KENTUCKY	44	0	0	
	WATERLOO UNIVERSITY	20	0	0	
	TOTAL	8,253	7,520	6,493	
SR-06	AGI-DATA REPOSITORY	0	1,500	1,000	33
	LAB/TBD-ADVANCED TECH	0	0	2,000	50
	LANL	265	265	203	71
	LLNL	350	350	350	50
	SNL	400	400	400	43
	M&O	2,800	5,145	1,778	21
	PRDA/TBD-FUND GEOSCIENCE	0	0	1,800	26
	RERI	60	100	100	79
	UNIV. OF KANSAS	0	250	0	9
	UNIV. OF OKLAHOMA	0	250	0	
	TOTAL	3,875	8,260	7,631	
SR-07	COLORADO SCHOOL OF MINES	29	0	0	50
	FORT VALLEY STATE UNIV.	0	13	0	30
	M&O	2,635	2,772	3,027	55
	SPE	15	15	0	94
	UNITAR	50	50	50	60
	UNIV. OF HOUSTON	0	40	0	95
	USGS	100	0	0	
	TOTAL	2,829	2,890	3,077	
SR-10	BUREAU OF INDIAN AFFAIRS	0	141	0	36
	DEA/TBD/PROJECTS	0	0	70	50
	HALLIBURTON	0	47	0	20
	LUFF	250	0	0	
	LAB/TBD-ADVANCED TECH	0	0	1,000	50

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
	M&O	3,065	2,695	3,014	31
	MONTANA BMG	0	168	0	20
	OERB	0	100	0	20
	STANFORD	425	442	460	27
	TBD-IMPROVE EXPLOR/DRILL	0	35	0	20
	WATERLOO UNIV.	0	20	19	80
	TOTAL	3,740	3,648	4,563	
SR-15	SNL/LANL	5,700	4,700	7,416	55
	TOTAL	5,700	4,700	7,416	
SR-17	ACT-LABS	4,065	0	0	60
	TOTAL	4,065	0	0	
	Tech and Program Management	361	268	252	
	GRAND TOTAL	35,432	33,483	34,023	

Q143. For those Exploration and Production Supporting Research funding recipients listed in the response to question 141 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A143. The recipients that were awarded on a non-competitive basis and the justification for that award are listed below:

SR-01: Computer Modeling Group–provide access to various reservoir simulation capabilities developed by CMG. There is no other alternative since the Computer Modeling Group is the only organization available with these simulation capabilities and membership opportunities.

SR-01/04: University of Houston/Composites Engineering and Applications Center (CEAC) –the technique is unique and extends a unique opportunity to complete research with well recognized research personnel which can have a major impact on the projects for research on composite materials. University of Houston/CEAC is uniquely qualified to head this board because of its location, past and current involvement in the U.S. petroleum industry, and faculty expertise in the areas of composites.

SR-01: Kansas Geological Survey–mandated by Congressional language in the FY 1995 Interior Appropriations. This project represents a unique idea and approach which would not be eligible for financial assistance under a recent, current, or planned solicitation.

SR-04/07: Colorado School of Mines–provides an opportunity for DOE to have an interactive exchange of research information with scientific community that will enhance the public benefits to be derived. CSM is uniquely qualified to offer training to earth science teachers that will further the goals of the DOE Education Initiative Project.

SR-04: University of Kentucky/Kentucky Geological Survey–will enhance the Tertiary Oil Recovery Information System (TORIS) database with the addition of approximately five more fields in western Kentucky and updates/enhancements to existing data. The KGS is uniquely qualified to head this activity because of past and current involvement in the US petroleum industry, and expertise in the area of TORIS data collection.

SR-04: University of Waterloo–offers a unique opportunity in that it will provide development of computer models for engineers to carry out sensitivity analysis, development of a quantitative means of calibrating the models to field behavior, use of the models to make prediction of well and field behavior, and will analyze specific field cases quantitatively. There is no other alternative since the University of Waterloo is the only university or business available.

SR-07: Society of Petroleum Engineers–Society of Petroleum Engineers and DOE will co-sponsor the "Tenth Symposium on Improved Oil Recovery". The Society of Petroleum Engineers is uniquely qualified to conduct this symposium. Previously it was funded under DE-FG22-94BC 14873 and is highly relevant to the DOE's current Oil Research Program to aid in the production of our oil and gas resources through advanced recovery technologies of reservoirs discovered to contain large volumes of remaining oil and gas.

SR-07: UNITAR Centre for Heavy Crude &Tar Sands–offers a unique opportunity in that it will facilitate the cooperative development of the world's heavy oil and tar sand resources, particularly to the benefit of energy deficient countries, in an efficient and environmentally sound manner. There is no other alternative since the UNITAR Centre is the only facility able to provide these services.

SR-04: Stanford University Petroleum Research Institute (SUPRI)–is uniquely qualified to head this activity because of past and current involvement in the US petroleum industry, and expertise in the area of thermal recovery. SUPRI has demonstrated experience in research techniques in thermal recovery and has the personnel, facilities and commitment to make this continued effort a success.

SR-06: American Geological Institute–noncompetitive award serving the public interest to assess the steps needed to preserve valuable geological and geophysical data and to offer future access to these data which are critical to the energy and economic prosperity of our Nation.

SR-06: Reservoir Engineering Research Institute–The Reservoir Engineering Research Institute is uniquely qualified to head this activity because of past and current involvement in the US petroleum industry, and expertise in the area of fractured reservoir research. The continued membership in this research project is relevant to the DOE missions and offers a unique opportunity in that it will provide a study of water Injection in mixed-wet fractured systems. There is no other alternative since the Reservoir Engineering Research Institute is the only organization available conducting this type of research.

SR-06: University of Kansas/Kansas Geological Survey–mandated by Congressional language contained in the FY 1996 Interior appropriations conference mark. This project represents a unique or innovative idea, method, or approach which would not be eligible for financial assistance under a recent, current, or planned solicitation.

SR-06: University of Oklahoma–congressionally mandated by Congressional language contained in the FY 1996 Interior appropriations conference mark, *"...$250,000 for continued work on the Gypsy field by the University of Oklahoma, all in advanced extraction and process technology..."*

SR-07: Fort Valley State College–offers a unique opportunity in that it will provide increased oil and gas company memberships from five to twenty-five in the Geoscience Consortium which will allow the Consortium to continue their beneficial work with reduced funding levels from government agencies. There is no other alternative since the Fort Valley State College is the lead organization in the Geoscience Consortium.

SR-07: University of Houston/Composites Engineering and Applications Center (CEAC)–the technique is unique and extends an unique opportunity to complete research with well recognized research personnel which can have a major impact on the projects for research on composite materials. University of Houston/CEAC is uniquely qualified to head this board because of its location, past and current involvement in the U.S. petroleum industry, and faculty expertise in the areas of composites.

SR-10: Halliburton Energy Services, Inc.–this project represents a unique idea and approach which would not be eligible for financial assistance under a recent, current, or planned solicitation.

SR-10: Montana Bureau of Mines and Geology–the technique is unique, and the Montana Bureau of Mines and Geology has the resources to conduct the planned research which will support their mission statement. They are uniquely qualified to head this activity because of current involvement in the US petroleum industry, and expertise in the area of oil and gas exploration.

Q144. Please describe the "technical and program management support" (page 75 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A144. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Recovery Field Demonstrations

Q145. Please provide a listing of the recipients of (i) the $28,289,000 in funding in FY 1995, (ii) the $11,075,000 in FY 1996 funding, and (iii) the requested level of $6,069,000 in FY 1997 for Recovery Field Demonstrations, including the funding for each recipient.

Q146. For each recipient of Recovery Field Demonstrations funds identified in the response to question 145 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A145. & A146. The list of recipients of the $28,289,000 funding in FY 1995, the $11,075,000 funding in FY 1996, and the $6,069,000 funding in FY 1997 for Recovery Field Demonstrations are listed below. Also listed is the level of funding provided by the recipient as cost-sharing for each of FY 1995-1997

Recovery Field Demonstrations Funding Recipients and Cost-Sharing
(In Thousands of Dollars)

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
FD-02	GSA	15	0	0	
	M&O	273	0	0	
	NATIONAL ACADEMY/SCIENCE	15	0	0	
	CLASS-PON/MORTG	8,470	3,287	0	57
	TOTAL	8,773	3,287	0	
FD-03	LOUISIANASTATE UNIV	950	0	0	57
	M&O	450	0	0	13
	CLASS-PON/MORTG	17,642	7,200	5,200	57
	TOTAL	19,042	7,200	5,200	
FD-04	M&O	135	0	0	
	TOTAL	135	0	0	

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
FD-07	M&O	0	0	700	50
	TOTAL	0	0	700	
FD-09	NPR-3	0	500	135	30
	TOTAL	0	500	135	
	Tech and Program Management	339	88	61	
	GRAND TOTAL	28,289	11,075	6,096	

Q147. For those Recovery Field Demonstrations funding recipients listed in the response to question 145 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A147. The recipients that were awarded on a non-competitive basis and the justification for that award are listed below:

FD-02: Geological Survey of America–offers an opportunity for DOE to aid teachers and administrators in a better understanding of what integrated science is and how it can be implemented in their classrooms. DOE knows of no other entity which is conducting or planning to conduct such a research effort. The Geological Society of America is especially qualified to conduct this series of workshops on integrated science for teachers and administrators.

FD-02: National Academy of Sciences/National Research Council–offers an opportunity for DOE to support assessment opportunities for multidisciplinary research by scientists in academia, industry, and government on the origin and evolutions of sedimentary basins. DOE knows of no other entity which is conducting or planning to conduct such a research effort. The National Academy of Sciences/National Research Council is especially qualified to conduct an assessment of this nature.

FD-03: Louisiana State University–will continue the development of improved reservoir characterization techniques and extraction processes to increase recovery in Gulf of Mexico reservoirs. It will benefit the public in that it will offer opportunities to significantly increase Gulf of Mexico production, delay platform abandonments, and preserve access to a substantial remaining oil target for both exploratory drilling and advanced recovery processes. It will continue research on significant innovations recently made in seismic processing and reservoir simulation, and advances made in deviated and horizontal drilling technologies, which will be applied to increase oil recovery in the Gulf of Mexico Basin.

Q148. Please describe the "technical and program management support" (page 77 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A148. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Exploration and Production Experimental Research

Q149. Please provide a listing of the recipients of (i) the $4,688,000 in funding in FY 1995, (ii) the $5,456,000 in FY 1996 funding, and (iii) the requested level of $6,456,000 in FY 1997 for Exploration and Production Environmental Research, including the funding for each recipient.

Q150. For each recipient of Exploration and Production Environmental Research funds identified in the response to question 149 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A149. & A150. The list of recipients of the $4,688,000 funding in FY 1995, the $5,456,000 funding in FY 1996, and the $6,456,000 funding in FY 1997 for Exploration and Production Environmental Research are listed below. Also listed is the level of funding by the recipient as cost-sharing for each of FY 1995 - 1997.

Exploration and Production Environmental Research Funding Recipients and Cost-Sharing
(In Thousands of Dollars)

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
ER-01	CA DOGGR	100	0	0	
	TOTAL	100	0	0	
ER-02	ICF/JV02	198	0	0	
	ICF/TBD	0	155	386	
	M&O	250	400	275	
	Kentucky	21	0	0	
	Texas	90	0	0	
	Ohio DNR	41	0	0	
	LSU	0	5	0	
	IOGCC	70	40	0	
	ARGONNE NL	0	50	0	
	LAWRENCE BERKELEY NL	0	150	100	
	WZI	50	0	0	
	TOTAL	720	800	801	

KA	RECIPIENT	FY95	FY96	FY97	COST-SHARE (%)
ER-03	TBD-ENVIRONMENTAL ANALAYSIS	0	100	300	
	OERB	0	100	0	87
	M&O	220	220	0	
	M&O/IOGCC	385	550	450	
	TOTAL	605	970	750	
ER-04	M&O	0	490	751	
	STATES TBD	0	564	0	
	CSA	410	0	300	
	GROUND WATER PROT. COUNCIL	320	425	500	
	KANSAS CORP. COMMISSION	107	160	232	40
	OKLAHOMA CORP COMMISSION	570	325	500	25
	STATE OF CALIFORNIA	155	200	570	70
	TEXAS RAILROAD COMMISSION	525	350	337	25
	UNIV. OF MISSOURI	200	127	0	
	LLNL	125	0	0	
	OERB	200	0	0	
	Lumitox	25	0	0	
	LSU	12	0	0	
	TOTAL	2,649	2,641	3,190	
ER-05	ARCO	105	284	0	60
	BNL	425	425	0	
	LAB-TBD	0	0	1,000	50
	M&O	36	241	350	
	RT	0	25	0	50
	TBD-REMEDIATION OF SOILS	0	0	300	
	M&O/IOGCC	0	15	0	
	TOTAL	566	990	1,650	
	Tech and Program Management	48	55	65	
	GRAND TOTAL	4,668	5,456	6,456	

Q151. For those Exploration and Production Environmental Research funding recipients listed in the response to question 149 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A151. None planned.

Q152. Please describe the "technical and program management support" (page 79 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A152. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

Processing Research and Downstream Operations

Q153. Please provide a listing of the recipients of (i) the $6,802,000 in funding in FY 1995, (ii) the $5,700,000 in FY 1996 funding, and (iii) the requested level of $5,962,000 in FY 1997 for Processing Research and Downstream Operations, including the funding for each recipient.

Q154. For each recipient of Processing Research and Downstream Operations funds identified in the response to question 153 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A153. & A154. The list of recipients of the $6,802,000 funding in FY 1995, the $5,700,000 funding in FY 1996, and the $5,962,000 funding in FY 1997 for Processing Research and Downstream Operations are listed below. Also listed is the level of funding provided by the recipient as cost-sharing fort each of FY 1995 - 1997.

Processing Research and Downstream Operations Funding Recipients
(In Thousands of Dollars)

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
DO-01	M&O	2,420	2,285	2,275	2
	CRADAS/LABS-MORTG	750	1,075	800	48
	BNL	500	500	400	32
	GRND WATER PROT. COUNCIL	75	75	0	
	TBD	0	33	0	
	ICF/TMS	131	250	0	
	MW KELLOGG	557	0	0	
	TBD/NATIONAL LABS	0	0	430	
	TOTAL	4,433	4,218	3,905	
DO-02	PERF/LABS	363	300	803	49
	ANL	24	0	0	
	LBNL	300	175	0	50
	M&O	700	300	300	
	TOTAL	1,387	775	1,103	
DO-03	CRADAS/LABS-MORTG	630	150	300	48
	ANL/LLNL	100	400	500	26
	M&O	183	100	100	
	TOTAL	913	650	900	

KA	RECIPIENT	FY95	FY96	FY97	COST SHARE (%)
	Tech and Program Management	69	57	54	
	GRAND TOTAL	6,802	5,700	5,962	

Q155. For those Processing Research and Downstream Operations funding recipients listed in the response to question 153 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A155. The recipients that were awarded on a non-competitive basis and the justification for that award are listed below:

DO-01: Ground Water Protection Council–is uniquely qualified to head this activity because of past and current involvement in the U.S. petroleum industry, and expertise in the area of waste disposal. The Ground Water Protection Council has demonstrated expertise in research techniques in waste disposal and has the personnel, facilities and commitment to make this continued effort a success.

Q156. Please describe the "technical and program management support" (page 81 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A156. The technical and program management support is an estimated 1% of program funding retained by Fossil Energy Headquarters for support of program related activities.

PROGRAM DIRECTION AND MANAGEMENT SUPPORT

Headquarters Program Direction

Q157. Please provide a listing of the recipients of (i) the $6,104,000 in funding in FY 1995, (ii) the $5,732,000 in FY 1996 funding, and (iii) the requested level of $5,201,000 in FY 1997 for Headquarters Program Direction Contract Services.

A157. In FY 1995, of the $6,104,000, $4,272,000 is for a working capital account, which is a chargeback system developed for use with the departmental account in Headquarters. Each program element provides for overhead and administrative activities through the program direction line of its individual funding request. The major business services provided through the working capital fund are: Building Occupancy; Printing and Graphics; Copying; Postage Supplies; Telephones; Contract Audit and Contract Closeout. The remaining balance included $115,000 for printing services at the Technical Information Center, $250,000 for computer timesharing and housekeeping services, and $1,467,000 for contract services that are generic to the entire FE program, which include computer services, technical and management support services, credit card buys, and journals and newsletters related to the Fossil Energy Program. In FY 1996, of the $5,732,000, $4,328,000 will be provided to the working capital account. The remaining balance includes $115,000 for printing services at the Technical Information Center, $181,000 for computer timesharing and housekeeping services, and $1,108,000 for contract services that are generic to the entire FE program, which include computer services, technical and management support services, credit card buys, and journals and publications related to the Fossil Energy Program. In FY 1997, of the $5,201,000, $2,947,000 will be provided to the working capital account. The remaining balance includes $160,000 for printing services at the Technical Information Center, $539,000 for computer timesharing and housekeeping services, and $1,555,000 for contract services that are generic to the entire FE program, which include computer services, technical and management support services, credit card buys, and journals and publications related to the Fossil Energy program.

Q158. For those Headquarters Program Direction Contract Services funding recipients listed in 157 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A158. There is only one recipient of some of the contract services funding on a non-competitive basis and that contractor is Peddada Consultants, Inc. This contractor is an 8(a) small disadvantaged company who qualified for a non-competitive contract award with Fossil Energy, due to its social economic status with the Small Business Administration. The work provided under this contract is for the maintenance and operation of Fossil Energy's Business Management Information System, and reports generated from that data base are used by all management officials.

ETC Program Direction

Q159. Please provide a listing of the recipients of (i) the $31,343,000 in funding in FY 1995, (ii) the $26,410,000 in FY 1996 funding, and (iii) the requested level of $19,328,000 in FY 1997 for ETC Program Direction Contract Services.

A159. The following is a listing of recipients of the $31,343,000 in FY 1995, the $26,410,000 in FY 1996, and the requested level of $19,328,000 in FY 1997 for ETC Program Direction Contract Services.

ETC Program Direction Funding Recipients
(In Thousands of Dollars)

Recipient	FY95	FY96	FY97
METC			
AGF Direct Gas Sales	55	130	0
Arabus LTD Partnership	28	0	0
ARD	0	40	0

Recipient	FY95	FY96	FY97
ATS, Inc.**	35	125	0
BFI - Fairmont District***	0	26	0
CTL Engineering of WV	10	30	0
D N American**	1,419	685	0
Digital Equipment Corp.	101	0	0
Dynamic Decisions, Inc.**	156	0	0
EG&G, Inc.	11,334	9,355	0
Hope Gas, Inc.***	7	100	0
K&M Eng. & Conslt. Corp.**	2	0	0
K-Ray Security**	218	550	0
Library of Congress****	100	100	0
Marada Corp.**	121	300	0
MEC Construction**	23	10	0
Monongahela Power Co.***	495	550	0
Morgantown Water Comm.***	0	20	0
Newbold Enterprises**	47	30	0
NRG Controls	50	0	0
PACE TEC**	1,681	1,397	0
S Powell Construction Co.**	559	0	0
Southern University	24	0	0
SPR Company**	5	0	0
Tri State Engineering**	231	200	0
Watkins Security Agency, Inc.**	185	0	0
Other Miscellaneous	0	741	0
Undistributed	0	0	5,921*
Total, METC	**16,886**	**14,389**	**5,921**
PETC			
Burns and Roe Services Corp.	6,646	6,078	0
Tri-Cor Industries, Inc.	1,747	892	0
Scott and Sons Maintenance, Inc	390	790	0
Authorization Systems, Inc.	189	0	0
Dynamics Concepts, Inc.	125	0	0
Burns and Roe Services Corp.	4	1	0
DOI/Bureau of Mines	1,661	1,886	0
Other (training, supplies, ORISE)	2,354	1,237	0
Undistributed	0	0	5,921
Total, PETC	**13,119**	**10,887**	**5,921**
BARTLESVILLE PROJECT FIELD OFFICE (BPO)			
ADP Purchases	95	90	0
BDM Oklahoma	150	150	0

Recipient	FY95	FY96	FY97
Brown and Root Marine	40	0	0
City of Bartlesville-Water/Sewage***	25	25	0
Gas Service Company***	50	50	0
Government Printing Office	150	150	0
GTE Telephone Mant. Serv.***	14	14	0
KG&E (Local Gas Co.)***	31	33	0
Lawrence Berkeley-Consultant	177	0	0
Miscellaneous Supplies	35	45	0
ORNL-Symposium	20	0	0
Office Equipment Main. (Fax, Copier, Typewriters, Video)	12	13	0
Paths of Change (Employee Assistance Program)	1	1	0
Public Service Company of Oklahoma (Electric)***	300	300	0
RSI Appraisal Group-Appraise Facility to sell	0	5	0
Southwestern Bell Tel.***	32	33	0
Teaco, Inc. (Computer Main)	2	1	0
Technical Information Center - OSTI Printing	115	115	0
US DOE - BMIS Contract Serv.	30	30	0
US DOE - FTS Phone Line	53	73	0
YMCA (Employee Health and Fitness Program)	6	6	0
Undistributed	0	0	6,869*
Total, BPO	**1,338**	**1,134**	**6,869***

*Level of funding will be contingent upon final appropriation. Based on the amount shown for Contractual Services in the FY 1997 Congressional Budget Request (after reducing the $19M by the $6M identified for the NIPER activity) any attempt to show figures in the table for FY 1997 would be purely arbitrary. The severe reduction shown in the 1997 Congressional Budget Request for Contract Services would have a substantial and detrimental impact on METC's ability to continue operations or acquire like services and support as were utilized in FY 1995 and 1996.

**Exception 5 to Competition in Contracting Act (as otherwise authorized by law, e.g., 8(a), JWOD).

***Local Utility.

**** Interagency Agreement.

Recipients without asterisks are competitive awards.

Q160. For those ETC Program Direction Contract Services funding recipients listed in 159 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A160. As shown in 159 above, contract services are competed with the exception of those identified with asterisks which were considered as non-competitive for the reasons annotated, i.e., they did not qualify for competition.

COOPERATIVE RESEARCH AND DEVELOPMENT

Q161. Please provide a listing of the recipients of (i) the $8,855,000 in funding in FY 1995, (ii) the $6,295,000 in FY 1996 funding, and (iii) the requested level of $4,000,000 in FY 1997 for Cooperative Research and Development.

A161. In FY 1995, of the $8,855,000, $2,802,000 is for providing support for Cooperative Research Programs at WRI and $2,557,000 for UNDEERC which are 50-50 cost-shared with non-federal clients. In addition, $977,000 is for providing support for noncost-shared research activities at WRI and $1,221,000 for UNDEERC. Also, $497,000 is to continue cost-shared cooperative agreement with the State of Illinois. Furthermore, $733,000 is for providing support for American Indian Schools and American Indian Owned Businesses, which includes competitive solicitations, regional and tribal training and symposiums; program evaluation and outreach; equipment; internships and fellowships; solicitation development, tribal input and response training, assistance and support. In addition, $68,000 is to fund technical and program management support.

In FY 1996, of the $6,295,000, $2,000,000 is for providing support for Cooperative Research Programs at WRI and $2,000,000 for UNDEERC which are 50-50 cost-shared with non-federal clients. In addition, $1,000,000 is for providing support for noncost-shared research activities at WRI and $1,000,000 for UNDEERC. Furthermore, $295,000 is to fund technical and program management support for Indian Energy Resources.

In FY 1997, of the $4,000,000, $1,980,000 is for providing support for Cooperative Research Programs at WRI and $1,980,000 for UNDEERC which are 50-50 cost-shared with non-federal clients. Furthermore, $40,000 is to fund technical and program management support for Indians Energy Resources.

Q162. For each recipient of Cooperative Research and Development funds identified in the response to question 161 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A162. In FY 1995, of the $8,855,000, $2,802,000 is for providing support for Cooperative Research Programs at WRI and $2,557,000 for UNDEERC which are 50-50 cost-shared with non-federal clients.

In FY 1996, of the $6,295,000, $2,000,000 is for providing support for Cooperative Research Programs at WRI and $2,000,000 for UNDEERC which are 50-50 cost-shared with non-federal clients.

In FY 1997, of the $4,000,000, $1,980,000 is for providing support for Cooperative Research Programs at WRI and $1,980,000 for UNDEERC which are 50-50 cost-shared with non-federal clients.

Q163. **For those ETC Program Cooperative Research and Development funding recipients listed in question 161 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.**

A163. The Cooperative Research and Development program is a unique program within Fossil Energy R&D. The program by its very nature is one in which the participants are either specified by legislation or are programs for which the Congress has directed funds for a specified purpose.

Q164. **Please describe the "technical and program management support" (page 90 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).**

A164. The technical and program management support provides for the costs of support services, printing, technical evaluations, SBIR assessments and all unusual but necessary expenses required to administer the Cooperative Research and Development program.

FOSSIL ENERGY ENVIRONMENTAL RESTORATION

CERCLA Remedial Actions

Q165. **Please provide a listing of the recipients of (i) the $3,085,000 in funding in FY 1995, (ii) the $5,572,000 in FY 1996 funding, and (iii) the requested level of $7,544,000 in FY 1997 for CERCLA Remedial Actions. Also please identify and describe each site involved.**

A165. The recipients for the FY 1995 and FY 1996 CERCLA funding were: the U.S. Army Corps of Engineers (USACE); EG&G Technical Services of WV (EG&G), Inc.; State of Wyoming Department of Environmental Quality (DEQ); the Western Research Institute (WRI) North Site; Baker and Associates, Inc.; Burns and Roe Services Corporation; MSE, Inc.; and the University of Tennessee Space Institute. The recipients for FY 1997 CERCLA funding are: the USACE; the State of Wyoming DEQ; Burns and Roe Services Corporation; MSE, Inc.; and the University of

Tennessee Space Institute. Off-site cleanup of a former PETC liquefaction site at Wilsonville, Alabama is to be performed in FY 1997 by a contractor yet to be determined.

The sites are listed and described below:

Rock Springs site in Wyoming–The Rock Springs site lies on 640 acres located seven miles west of Rock Springs, WY. The groundwater at the site is contaminated with benzene, toluene, xylene, and other organics as a result of government-sponsored in-site oil shale retort tests.

Hoe Creek site–The Hoe Creek site lies on 83 acres located 20 miles south of Gillette, WY. The groundwater is contaminated with benzene and other organics as a result of government-sponsored Underground Coal Gasification tests.

Western Research Institute (WRI) North–The WRI North site is situated on a 21 acre formerly owned federal facility (FOFF) located one mile north of Laramie, WY. Buildings, structures, equipment, and soils are contaminated with organics and heavy metals as a result of government-performed and government-sponsored research. This activity is expected to be completed in FY 1996.

University of Tennessee Space Institute (MHD)–This site is located 6 miles east of Tullahoma, Tennessee and was used by the DOE for testing of coal-fired magnetohydrodynamic power generation from 1981 until 1993. Groundwater monitoring detected elevated concentrations of inorganic and organic constituents in monitoring wells. Concentrations of carbon tetrachloride, tetrachloroethylene, and dichloroethylene exceed State of Tennessee's Primary Drinking Water standards.

Component Development and Integration Facility (MHD)–This site is located on 53 acres of property 3 miles south of Butte, Montana and was operated from 1976 until 1993 for the testing of coal-fired magnetohydrodynamic components. Site characterization indicated releases from coal basins and the need to cleanup wastewater containment ponds, characterize and remediate stormwater drainage system, and remove the underground storage tanks.

PETC Liquefaction site–Operation of this coal and liquefaction research and development facility near Wilsonville, was supported by the DOE from 1976 until the early 1990's. Contamination, consisting chiefly of petroleum hydrocarbons, including polycyclic aromatic hydrocarbons, is present in the soil beneath the facility's former operating units. Chlorinated solvent contamination was also found in groundwater monitoring wells.

Indiana hazardous waste cleanup–The DOE provided funding for the Institute of Gas Technology/Hydrogen DONUT Gasification Project that contributed to soil and groundwater contamination at the Ninth Avenue Dump Superfund Site located in Gary, Indiana.

Q166. For those CERCLA Remedial Actions funding recipients listed in question 165 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A166. METC's non-competitive CERCLA activities include those conducted at the Hoe Creek Site, the Rock Springs Site, and the Western Research Institute (WRI) North Site (WRI). For the Hoe Creek and Rock Springs Site the NETC approach is a non-competitive U.S. Army Corps of Engineers (USACE) Interagency Agreement to utilize USACE expertise and organization. The decision to establish this agreement with the USACE was made to preclude the need for establishing redundant contracts, to achieve lower cost performance, and to implement required activities on a schedule-efficient basis. This Interagency Agreement was established pursuant to an existing Memorandum of Understanding between the DOE and the USACE for supporting environmental restoration activities. Although the agreement with USACE is non-competitive, the USACE awards are through competitive or 8(a) small business procurements. The WRI North Site clean-up is being accomplished under a Cooperative Agreement between the DOE-METC and the WRI.

PETC's non-competitive CERCLA activities include those involving MHD cleanup by MSE, Inc. and the University of Tennessee Space Institute. The MSE, Inc., activity is non-competitive based upon the scope of the contract, their residence as site operator, and to alleviate redundancy in costs that would have been incurred if another organization was selected through competitive procurement for these activities. Substantial schedule delay, with potentially expanded contamination, would have resulted from a competitive procurement process. The University of Tennessee Space Institute is the owner and operator of the site used for coal-fired magnetohydrodynamics testing at Tullahoma, Tennessee. Competitive award for closeout and cleanup activities was precluded by this agreement and by the scope of the contract with the Institute. Award of a contract to another organization from competitive procurement would have resulted in increased costs incurred for closeout and cleanup, and potentially expanded the area of contamination due to schedule delays in implementation of the activities.

RCRA Remedial Actions

Q167. Please provide a listing of the recipients of (i) the $2,704,000 in funding in FY 1995, (ii) the $2,258,000 in FY 1996 funding, and (iii) the requested level of $1,755,000 in FY 1997 for RCRA Remedial Actions. Also please identify and describe each site involved.

A167. At METC, the recipients for the FY 1995 RCRA funding were: the U.S. Army Corps of Engineers (USACE); Advanced Technology Systems (ATS), Inc.; AE Environmental, Inc.; Parsons Power; Monitoring Instruments for the Environment (MIE), Inc.; EG&G Technical Services of WV (EG&G), Inc.; MEC, Inc.; and Steve Powell Construction (SPC), Inc. The recipients for the FY 1996 RCRA funding are the USACE; ATS, Inc.; EG&G, Inc.; and others yet to be determined. The recipients for the requested FY 1997 RCRA funding are: the USACE, with several yet to be determined. All RCRA activities are performed on-site.

At PETC, the recipients for the FY 1995 and FY 1996 RCPA funding were: Baker and Associates, Inc.; Burns and Roe Services Corporation; Power Contracting Company; and Scott and Sons Maintenance, Inc. The recipients for the requested FY 1997 RCRA funding are yet to be determined. All RCRA activities are performed on-site.

Q168. For those RCRA Remedial Actions funding recipients listed in question 167 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A168. METC non-competitive RCRA activities include all those involving the U.S. Army Corps of Engineers (USACE) due to an Interagency Agreement; however, the USACE subcontracts are competitive. The decision to establish this agreement with the USACE was made to preclude the need for establishing redundant contracts, to achieve lower cost performance, and to implement required activities on a schedule-efficient basis. This Interagency Agreement was established pursuant to an existing Memorandum of Understanding between the DOE and the USACE for supporting environmental restoration activities. Other non-competitive RCRA activities involve: Advanced Technical Systems (ATS), Inc.; AE Environmental, Inc.; MEC Inc.; and Steve Powell Construction (SPC), Inc., all of which are non-competitive because of Department guidelines recommending the use of 8a firms. A third set of non-competitive RCRA activities involves Monitoring Instruments for the Environment Inc. which is non-competitive due to specific equipment/instrumentation that METC needed to purchase to meet Departmental specifications.

Other ES&H Actions

Q169. Please provide a listing of the recipients of (i) the $5,978,000 in funding in FY 1995, (ii) the $7,089,000 in FY 1996 funding, and (iii) the requested level of $5,728,000 in FY 1997 for Other ES&H Actions. Also please identify and describe each site involved.

A169. At METC, the recipients of the FY 1995 Other ES&H Actions funding were: EG&G Technical Services of WV (EG&G), Inc.; Underwriter Laboratory; AG Mauro; Neely's Locksmith; Tom Brown, Inc.; Parsons Engineering; Steve Powell Construction (SPC), Inc.; and Advanced Technical Systems (ATS), Inc. The recipients for the FY 1996 and FY 1997 Other ES&H Actions funding are EG&G, Inc.; SPC, Inc.; and ATS, Inc. All activities are performed on-site.

At PETC, the recipients for the FY 1995 and FY 1996 Other ES&H Actions funding were: Baker and Associates, Inc.; Burns and Roe Service Corporation; and the U.S. Army Corps of Engineers. The recipients for the requested FY 1997 Other ES&H Actions funding are yet to be determined. All activities are performed on-site.

At BPO/NIPER, the recipient for the FY 1995, FY 1996, and FY 1997 funding is BDM Oklahoma. All activities are performed on-site.

Q170. For those Other ES&H Actions funding recipients listed in question 169 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A170. METC non-competitive Other ES&H Actions funding recipients included the Underwriter Laboratory due to the fact that this is a nationally recognized association providing industry adopted fire protection documentation. Other activities involving Steve Powell Construction (SPC), Inc. and Advanced Technology Systems (ATS), Inc. were non-competitive because of Department guidelines recommending the use of 8a firms. Finally the activity involving ERASE is non-competitive because there are no other contractors in the area that are capable of performing the Site Hazard Assessment.

PETC non-competitive Other ES&H Actions include the U. S. Army Corps of Engineers (USACE), Pittsburgh District due to an Interagency Agreement. However, subcontracts are competitive. The decision to establish this agreement with the USACE was made to preclude the need for establishing redundant contracts, to achieve lower cost performance, and to implement required activities on a schedule-efficient basis.

This Interagency Agreement was established pursuant to an existing Memorandum of Understanding between the DOE and the USACE for supporting environmental restoration activities.

Q171. Please describe the "technical and program management support" (page 93 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A171. The "technical and program management support" category of the Fossil Energy Environmental Restoration Budget addresses those crosscutting environment, safety, security and health (ESS&H) functional activities performed by Headquarters in support of Fossil Energy (FE) programs. These activities are performed in coordination with the FE field sites and include: (1) developing FE ESS&H policy, guidance and strategic plans; (2) preparing NEPA documents; (3) providing ESS&H performance and compliance information; (4) coordinating the FE ES&H planning and budget process; (5) providing liaison with DOE/external ESS&H organizations; and (6) managing specific off-site remediation projects.

Magnetohydrodynamics (MHD) Closeout and Cleanup Actions

Q172. Please provide a listing of the recipients of the $3,534,000 in funding in FY 1995 for Magnetohydrodynamics (MHD) Closeout and Cleanup Actions. Also please identify each site involved.

A172. The sites involved are: Tullahoma, Tennessee; Butte, Montana; Everett, Massachusetts; and Haverhill, Massachusetts. The contractors performing the work in FY 1995 were MSE, Inc., University of Tennessee Space Institute, Argonne National Laboratory, and Burns and Roe Services Corporation.

Q173. For those Magnetohydrodynamics (MHD) Closeout and Cleanup Actions funding recipients listed in question 172 above, please identify those that were awarded on a non-competitive basis, and provide a justification for each such non-competitive award.

A173. MHD Closeout and Cleanup Actions funding was awarded on a non-competitive basis to MSE, Inc., University of Tennessee Space Institute, and Argonne National Laboratory.

The MSE, Inc., activity is non-competitive based upon the scope of the contract, their residence as site operator, and to alleviate redundancy in costs that would have been incurred if another organization was selected through competitive procurement for these activities. Substantial schedule delay, with potentially expanded contamination, would have resulted from a competitive procurement process.

The University of Tennessee Space Institute is the owner and operator of the site used for coal-fired magnetohydrodynamics testing at Tullahoma, Tennessee. Competitive award for closeout and cleanup activities was precluded by this agreement and by the scope of the contract with the Institute. Award of a contract to another organization from competitive procurement would have resulted in an increase and redundancy of the costs incurred for closeout and cleanup and potentially expanded the area of contamination due to the schedule delay in implementing the activities.

Argonne National Laboratory activity is non-competitive based upon their historic involvement and subsequent expertise as a DOE Laboratory in the MHD program and in cleanup assessments.

FUELS PROGRAM

Q174. Please provide a listing of the recipients of (i) the $2,995,000 in funding in FY 1995, (ii) the $2,687,000 in FY 1996 funding, and (iii) the requested level of $2,188,000 in FY 1997 for the Fuels Program, including the funding for each recipient.

A174. The Office of Fuels Programs administers regulatory programs under Executive Order 12038, the Federal Powers Act, the Natural Act, and the Powerplant and Industrial Fuel Use Act. The Office engages in no research or development activities. Funding is provided for Federal employees' salaries, to Argonne National Laboratory (ANL) for support in compliance with the National Environmental Policy Act, and to Technology and Management Services, Inc. (TMS) for general support services. The following shows the recipients of the Office's funding for FY 1995, FY 1996, and FY 1997.

Recipients	**FY 1995**	**FY 1996**	**FY 1997**
Federal Salaries	$2,177,500	$2,071,100	$1,633,400
ANL	$600,000	$387,000	$300,000
TMS	$217,500	$228,900	$254,600
Total	**$2,995,000**	**$2,687,000**	**$2,188,000**

Q175. For each recipient of Fuels Program funds identified in the response to question 174 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A175. The funds expended by the Office of Fuels Programs are for Federal salaries and direct contractor services. The Office is not engaged in any activities or programs for which cost-sharing could be implemented.

Q176. For those Fuels Program funding recipients listed in the response to question 174 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A176. As indicated in the response to question 174, the only external funding provided by the Office of Fuels Programs is to Argonne National Laboratory for support of environmental impact analyses and to Technology and Management Services, Inc. for general support services. Support service contractors are selected by the Office of Fossil Energy utilizing standard competitive practices.

Q177. Please describe the "technical and program management support" (page 96 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A177. The "technical and program management support" funds are for general system support to programmatic services.

MINING RESEARCH AND DEVELOPMENT

Materials

Q178. Please provide a listing of the recipients of (i) the $5,000,000 in funding in FY 1996, and (ii) the requested level of $5,000,000 in FY 1997 for Materials, including the funding for each recipient.

A178. The funding in the FY 1996 budget for the materials program pays only the salaries of the 85 full time equivalent employees transferred to the Department of Energy in accordance with Public Law 104-99.

Q179. For each recipient of Materials funds identified in the response to question 178 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A179. Since the funding provided money for the salaries of Federal employees there is no cost sharing in this program.

Q180. For those Materials Program funding recipients listed in the response to question 178 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A180. Since the funding provided is for the salaries of Federal employees there were no non-competitive awards in this program.

Q181. Please describe the "technical and program management support" (page 99 of Volume 4 (of 5) of the *FY 1997 Congressional Budget Request*, for FY 1995-FY 1997).

A181. The $50,000 in this activity for technical and programmatic support for this program will provide funding for the incidental needs for this program such as systems support and to provide for integration into the Fossil Energy program.

Health & Safety

Q182. Please provide a listing of the recipients of the $35,000,000 in funding in FY 1996 for Health & Safety, including the funding for each recipient.

A182. The funding associated with the former Bureau of Mines offices located in Spokane, Washington and Pittsburgh, Pennsylvania ($35,000,000) is to pay for the salaries of approximately 442 Federal employees located at these two sites.

Q183. For each recipient of Health & Safety funds identified in the response to question 182 above, please provide the level of funding provided by that recipient as cost-sharing for each of FY 1995-FY 1997.

A183. Since these funds are used to pay Federal salaries, there is no cost sharing involved in this program.

Q184. For those Health & Safety funding recipients listed in the response to question 182 above, please identify those that were awarded funds on a non-competitive basis, and provide a justification for each such non-competitive award.

A184. There were no funds awarded on a non-competitive basis.

APPENDIX 4
FOLLOWUP QUESTIONS AND ANSWERS FOR THE RECORD

Mr. Allen Li
Associate Director
Energy, Resources and Sciences Issues
Resources, Community, and Economic Development Division
U.S. General Accounting Office

Answers to Followup Questions

GAO
United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

August 26, 1996

The Honorable Dana Rohrabacher
Chairman, Energy and
Environment Subcommittee
Committee on Science
House of Representatives

Dear Mr. Rohrabacher:

This letter responds to your August 6, 1996, request asking that we provide follow-up information on issues arising from an April 17, 1996, hearing before your Subcommittee. The hearing focused on the Department of Energy's fiscal year 1997 budget requests for Energy Efficiency and Renewable Energy and Fossil Energy Programs. Enclosed are our responses to the Subcommittee's questions.

Should you have additional questions or want to discuss our responses further, please call me at (202) 512-3841.

Sincerely yours,

Allen Li

Allen Li
Associate Director, Energy,
Resources, and Science Issues

Enclosure

GAO'S RESPONSES TO THE SUBCOMMITTEE'S QUESTIONS

In a Department of Energy (DOE) letter to GAO dated April 16, 1996, signed by Ms. Ervin, Ms. Godley, and Mr. Chupka, it is stated in the last paragraph on page 2:

> "We understand that the GAO was under pressure to finalize this report and note that it was released one week prior to the expected markup of the FY 1997 Budget Resolution."

Question 1a: Is there any basis for the allegation that "GAO was under pressure to finalize this report."

GAO's Response: GAO's goal is to provide quality, timely products to the Congress. In September 1995, Chairman Kasich's staff of the House Budget Committee requested that we complete this work in time for potential hearings in the February/March time frame. The scope of our work was defined with that time frame in mind. In mid-February, we briefed the requester's staff on our findings and the staff asked us to prepare for a hearing in mid- to late March. In early March, we were told that the hearing would probably be in April. On March 29, 1996, the requester's staff asked that we prepare a written report. We subsequently agreed to provide the report by April 15, 1996.

Question 1b: If there is any basis for this allegation, who specifically applied this "pressure"? Did any Members of this Subcommittee or staff "pressure" GAO to finalize this study, and, if so, would you please identify them and provide detailed documentation of such "pressure"?

GAO's Response: There is no basis for the allegation.

Question 1c: If there is no basis for the allegation of "pressure," why do you think that DOE officials would have raised the issue in a public document?

GAO's Response: We have not discussed this allegation with DOE officials. As noted in DOE's letter to GAO dated April 16, 1996, we had worked openly and closely with DOE for seven months. For example, on March 1, 1996, we briefed DOE officials on the results of our audit. On April 4, 1996, we provided a draft report to DOE. We requested and DOE agreed to provide comments by April 10, 1996. DOE's comments are reflected in our April 15, 1996, report.

Question 2: In a follow-up to the previous question, could you please tell us if GAO was under pressure from anyone in the Department of Energy, in Congress (Members or staff), or from outside the government to not finalize the report, and if so, would you please identify those individuals?

GAO's Response: We were not under pressure from anyone in the Department of Energy, in the Congress (members or staff), or from outside the government to not finalize the report.

Question 3: Why did GAO only select 15 of the 61 "Success Stories" for audit, and what criteria were used for the selection?

GAO's Response: Due to the original due date for a product, we proposed to review a sample of the 61 case studies cited in the DOE Success Stories report. The requester's staff agreed with this approach. We selected 15 cases that provided a cross section of DOE's applied R&D programs and allowed for the analyses of many of the largest claims of benefits.

Question 4: What criteria did a "Success Story" have to meet in order to receive a rating of "Adequate Support for All Benefits Claimed"?

GAO's Response: A technology was determined to have "Adequate Support for All Benefits Claimed" if DOE's supporting documentation for the benefits cited in Success Stories did not contain any basic math errors, problems in the supporting economic analyses, or unsupported links between the benefits cited and DOE's role or the technology.

Question 5: Please elaborate on the problems encountered with the following "Success Stories":

a. Florescent lamp electronic ballasts.
b. Nickel metal hydride batteries.
c. Electrochemical dezincing of steel scrap.
d. Advanced energy-efficient windows.
e. High-efficiency refrigerator compressors.

GAO's Response:
a. Florescent lamp electronic ballasts. DOE's claim did not include an analysis of the higher cost of the technology to the consumer. For example, DOE did not consider that a fluorescent electronic light ballast costs a consumer $8 more than the conventional magnetic ballast. When this price premium is considered, consumers spent $52 million more for fluorescent lamp electronic ballasts than they saved in energy bills during the period DOE examined (January 1988 to April 1995).

b. Nickel metal hydride batteries. We believe that the California mandate for electric vehicles created a potential market for all technologies for these vehicles, not just the nickel metal hydride battery. However, the potential market does not mean that this battery or any technology will be technically feasible or economically viable. These two points form the basis for our conclusion that DOE did not adequately support the benefits claimed.

Industry analysts also question whether this battery will ever be competitive in an open market that includes gas-powered cars. In a recent report, we said that at the price projected for the battery, large subsidies will be needed to sell the electric vehicles that use the battery.[1] Although research has developed a battery that can meet mid-term performance goals, many industry analysts question whether the battery will enable electric vehicles to perform well enough to have wide appeal to large numbers of consumers. It remains unclear whether the feasibility of a long-term battery–one that can compete in performance and cost with gas-powered vehicles–will be demonstrated.

Also, DOE estimated the price of the battery at $7,500 each. Our concerns were that this price (1) does not reflect the cost of the battery at today's level of technology ($12,000); (2) exceeds the Advanced Battery Consortium's mid-term goal by $3,000; and (3) would require large subsidies to make electric vehicles marketable, according to industry experts.

c. Electrochemical dezincing of steel scrap. Our conclusion was based on the fact that DOE could not support its assertion in Success Stories that all zinc produced from steel scrap would displace imported zinc. In our review, we learned that over two-thirds of the zinc consumed in the United States is imported. This figure suggests that imported zinc is at least competitive on price and other terms with domestically produced zinc. Even if the new process allows zinc to be produced at a lower cost than the existing domestic or imported sources, there is no reason to believe that the new production would displace only imports.

d. Advanced energy-efficient windows. As with the case study on the ballast, DOE did not include an analysis of the higher cost of the low-emissivity windows to the consumer.

e. High-efficiency refrigerator compressors. As stated in our report, DOE adequately supported the benefits claimed in Success Stories for the high-efficiency refrigerator compressors.

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[1] Electric Vehicles: Efforts to Complete Advanced Battery Development Will Require More Time and Funding (GAO/RCED-95-234, August 17, 1995).

Dr. Ronald L. McMahan
President and Founder
Resource Data International, Inc.

Answers to Followup Questions

RESOURCEDATA
[illegible]

August 29, 1996

Dr. Harlan L. Watson
Energy and Environment Subcommittee
Committee on Science
B374 Rayburn H.O.B.
Washington, DC 20515-6301

Dear Dr. Watson:

Please find enclosed my responses to the follow-up questions sent with your August 6, 1996 letter. I have also enclosed a copy of our response to the NREL critique of our study, Energy Choices in a Competitive Era, per your request.

Please call with any questions.

Sincerely,

Ronald L. McMahan, Ph. D.
President

HEARING OF THE SUBCOMMITTEE ON ENERGY & ENVIRONMENT
COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES
ON

THE DEPARTMENT OF ENERGY'S FY 1997 BUDGET REQUESTS FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY AND FOSSIL ENEREGY PROGRAMS

WEDNESDAY, APRIL 17, 1996

DR. RONALD L. McMAHAN
PRESIDENT
RESOURCE DATA INTERNATIONAL, INC.

RESPONSE TO FOLLOW-UP QUESTIONS OF THE COMMITTEE

1. *On page 2 of Ms. Ervin's testimony, she stated: "Prices from energy delivered by renewable energy technologies have dropped by orders of magnitude, from 90 cents per kwh to 20 cents in 1995; from 40 cents per kwh to 5-6 cents in 1995, for wind; from 9 cents per kwh to 5 cents for geothermal energy."*

   However, according to your testimony, your study of the comparative levelized costs, including subsidies, of renewable electricity generation found 27.4 cents per kwh for photovoltaics and 8 cents for geothermal energy.

   How do you explain the disparity and how much would the delivered prices be in the absence of taxpayer subsidies?

   It is true that the gains achieved by renewable energy technologies ("RETs") since the early 1980s have been dramatic, and this is something of which the renewables industry can be proud. Certain RETs, particularly wind, have even achieved economic viability targets set in the late 1980s to early 1990s. Unfortunately, the competitive price of power has dropped from 5 cents per kwh in the 1990 timeframe to about 3 cents or lower today and will drop further in the future as the result of electric utility deregulation.

   Further, as is true with any new technology, the easiest and largest gains come early in the development process, with additional improvements and cost reductions becoming increasingly more difficult. This is the current position of many RET companies. For example, Kenetech, the largest U.S. wind company, has reportedly filed for bankruptcy due to serious difficulties with its latest generation of variable speed rotors.

   In direct response to the disparity between RDI's levelized production cost estimates and those stated by Ms. Ervin, note that any calculation of levelized costs is highly dependent upon a number of assumptions and that different analysts will have different assumptions. For this reason, RDI provided detailed sensitivity analyses in our study, *Energy Choices in a Competitive Era.*[1] Specifically, we tested our results for sensitivities to assumptions for discount rates, taxes and tax incentives, cost of capital during construction, and capacity factors.

For photovoltaics, our results ranged from a low of 16.1 cents under a public power scenario (i.e., no taxes paid) to a high of 35.4 cents under a 9% discount rate. The figure of 27.4 cents represents our base case of investor-owned plant development at a 6% discount rate with no costs of capital during construction. Given this range, Ms. Ervin's stated cost of 20¢ per kwh is consistent with our results. We cannot comment further without knowing the exact assumptions used to calculate the 20 cent figure.[2] The same applies for geothermal, where Ms. Ervin's cited figure of 5 cents is somewhat outside our calculated sensitivity range of 5.6 cents to 8.9 cents.

In the final analysis, the important thing is to compare the relative ranking of each technology under a consistent set of assumptions. Therefore, where our sensitivity analysis for a lower discount rate dropped the levelized cost of photovoltaics from 27.4 cents to 20.5 cents, it also dropped the cost of pulverized coal technology from 3.8 cents to 3.3 cents. No matter what assumptions we may consider that could favor solar photovoltaics, the fact remains that this technology's costs are far out of reach of economic viability in the open market.

In regard to the question regarding prices in the absence of taxpayer subsidies, RDI notes the key phrase "taxpayer subsidies" in responding that our estimates for wind and dedicated energy crop biomass projects include a tax credit of 1.5 cents per kwh, as provided in the federal Energy Policy Act of 1992. The federal government also provides a 10% investment tax credit for certain RETs, including solar, as well as allocations of sulfur dioxide emission allowances as a "reward" for RET generation under Title IV of the Clean Air Act Amendments of 1990.

However, the majority of subsidies for RETs are derived not from taxpayers, but from ratepayers. California's infamous ISO 4 power purchases contracts, for example, provide prices to RET projects that are double and even triple the current market price for power. Likewise, Minnesota's set-aside for renewables also forces above-market costs onto ratepayers.

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[1] See Technical Appendix section of *Energy Choices in a Competitive Era*, pp. 13-17.

[2] In addition, assumptions for location and plant capacity are also important. Again, we do not know the assumptions used for the 20 cent figure cited by Ms. Ervin.

2. *Would you please comment on the viability of biomass to play a major role in either electricity generation or in fuel ethanol production?*

Biomass constitutes almost half of all U.S. installed RET generating capacity, but only about 1% of total U.S. generating capacity. It cannot play a major role in electricity generation for both economic and practical reasons.

The most economic biomass plants today are those that combust the waste products of agriculture, such as the lumber residues. Thus, the cost of fuel consists primarily of the cost to transport waste from the processing facility to the generating plant. The relationship is symbiotic in that the processing facility defrays its waste disposal costs through electricity sales and the generating plant gains low cost fuel.

Such situations are limited by the availability of agricultural waste and the ability to site a plant within an economic distance from the processing facility(ies) on which it relies (transportation costs generally become prohibitive beyond 50 miles). Further, not all agricultural waste is well-suited to combustion, given extremely high moisture content and handling problems, e.g., stockpiling and chipping grape vines is no easy task. Some waste products are even corrosive in boilers. Finally, biomass combustion technologies are not much different from coal combustion technologies. Therefore, it is difficult for a biomass plant burning waste with 4,000 Btu/lb. to achieve competitive efficiencies against a similar plant burning coal with 12,500 Btu/lb.[3]

In recent years, the concept of a generating facility fueled by a dedicated energy crop has gained some interest, primarily from parties concerned about CO_2 emissions. The perceived advantage of this configuration is that the CO_2 emitted by the generating plant should be absorbed by the crops, such as trees or grains, cultivated by the plant for future consumption. In other words, the generating plant would theoretically present zero net emissions of CO_2.

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[3] Between 1991-1994, the combined capacity of biomass plants in California dropped from 850 megawatts to 635 megawatts due to the unviability of the plants. The California Biomass Energy Alliance predicted that total capacity would fall to 100 megawatts by the year 2000.

Again, economic and practical issues make development of such a plant doubtful. Unlike plants that burn waste, dedicated energy crop plants do not enjoy cost sharing with processing plants. The cost of fuel for such plants rises to as much as three times the cost for waste fuel, given the added costs of growing and harvesting the agricultural fuel which include the cost of land ownership, pesticides, fertilizer, and labor, among others.

As a practical matter, finding sites for plant-farm/forest complexes should be somewhat difficult, since the site must be large and accommodate both agriculture and industrial activity.[4] Most likely, any such site would be quite remote, with attendant costs for transmission, road, and water access. Plus, even the largest sites could only accommodate a moderately sized generating facility. Again, fuel sourced from outside the complex is economically limited to a haul of 50 miles or less given the low heat content of the fuel.

The net-emissions concept itself is also open to debate. One wonders why crops planted as CO_2 absorbers must be combusted at uneconomic costs to generate electricity – rather than just planting them to absorb CO_2 and then combusting much more economical fossil fuels. Certainly, the image of harvesting forests for combustion conflicts with the environmentally sensitive motivation of those promoting dedicated fuel crop biomass.

Finally, the economics of both waste and dedicated energy crop biomass plants are limited partly due to an inability to gain sufficiently high utilization rates. Because agriculture tends to be seasonal, the fuel supply for biomass plants can vary significantly throughout the year, resulting in low utilization rates during off-seasons. For waste fuels, economic cycles also come into play, with less fuel available during recessions or lulls in housing starts. As reviewed in the sensitivity analyses of *Energy Choices*, lower utilization rates equate to higher levelized production costs.

RDI supports biomass power plant development where production costs are competitive in open power markets or where that portion of the production costs that is above market levels is absorbed by the industry generating the waste fuel.

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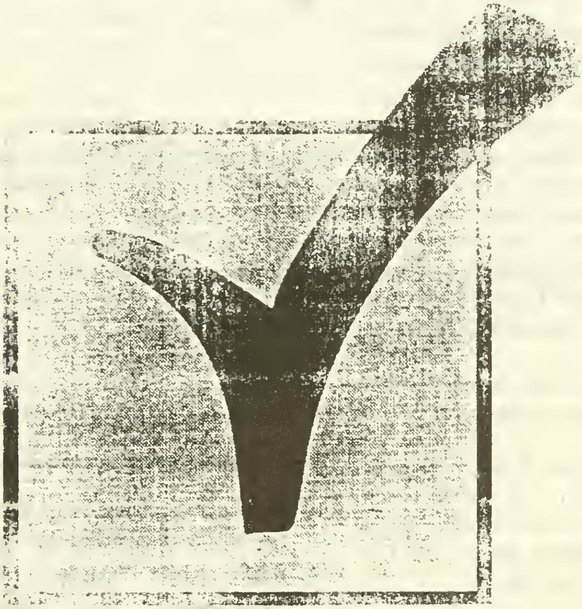
[4] This also assumes that cultivation of energy crops would be the most economic use of the land in question. It is possible that other agricultural or development interests could bid-up the price of the land to a point above the economic viability of the biomass complex.

RDI has not investigated the potential for biomass to play a major role in fuel ethanol production.

3. *It is our understanding that the Department commissioned a report by the National Renewable Energy Laboratory (NREL) entitled "The True Cost of Renewables: An Analytical Response to the Coal Industry's Attack on Renewable Energy," which was published in October 1995 (NREL/TOP-462-20032) in response to the RDI study "Energy Choices in a Competitive Era: The Role of Renewables and Traditional Energy Resources in America's Electric Generation Mix." It is also our understanding that RDI prepared a response to [the] NREL report on behalf of The Center for Energy & Economic Development (CEED). Could you please provide a copy of this response?*

Please see the enclosed copy of our response to NREL.

REALITY CHECK



A Reply to the National Renewable Energy Laboratory's Critique of *Energy Choices in a Competitive Era*

RESOURCE
INTERNATIONAL INC

ENERGY &
ECONOMIC

THE CENTER FOR ENERGY & ECONOMIC DEVELOPMENT

November 10, 1995

A serious debate about renewable energy's role in electricity generation in our nation has recently been renewed and heightened. That is important news for policy makers across the country and for the American populace-at-large.

Last April, Resource Data International, Inc. (RDI) released a study that CEED commissioned entitled *Energy Choices in a Competitive Era: The Role of Renewable and Traditional Energy Resources in America's Generation Mix*. The RDI study came to several major conclusions including the following:

✔ Technological and logistical obstacles will significantly limit the ability of non-hydro renewable energy resources to produce electricity for the grid.

✔ Despite these problems, non-hydro renewables will increase their market share from 2% to 4% by 2010 in RDI's base case.

✔ Even if technological and logistical obstacles can be overcome, the cost over the next 15 years to utilities, taxpayers and ratepayers of such a market increase by non-hydro renewables will be about $52 billion (in 1995$) over today's most competitive power alternatives.

While NREL took dead aim and fired on RDI's credibility by stating that RDI used "faulty" data and assumptions, they missed their target badly. *The RDI research is well grounded and compelling. CEED stands four-square behind RDI and the findings of their study.*

✔ Renewable technologies have adverse environmental impacts, as do all other technologies in the generation of electricity.

After an initial response to the RDI study from some renewable energy advocacy groups, public debate on this issue stalled as focus shifted to the implications of

1800 DIAGONAL ROAD [illegible]
ALEXANDRIA [illegible]
TELEPHONE (703) [illegible]

utility competition on future fuel choices. Earlier this week, however, the National Renewable Energy Laboratory (NREL) released a paper entitled *The True Cost of Renewables: An Analytic Response to the Coal Industry's Attack on Renewable Energy*. The NREL paper was sponsored by the United States Department of Energy.

FACT:
The U. S. Department of Energy's own Energy Information Agency predicts that renewables will have a market share of just 5% by 2010.

The Center for Energy and Economic Development welcomes review of our research documents; such analysis is good for public discourse and good for the future of America. While NREL took dead aim on RDI's credibility by stating that RDI used "faulty" data and assumptions, they missed their target badly. *The RDI research is well grounded and compelling. CEED stands four-square behind RDI and the findings of their study.*

In the following pages, RDI provides a detailed response to the allegations made by NREL. As a preface to the response, please note the following false NREL allegations:

ALLEGATION#1: *Energy Choices* is an "attack" on renewables.

FACT: *Energy Choices* found in its base case that renewables' market share will double from 2% to 4% by 2010.

FACT: *Energy Choices* affirmatively states that renewables have a niche role to play in America's energy future.

ALLEGATION #2: Renewables' market share will grow much more rapidly than *Energy Choices'* prediction of 4%.

FACT: The U. S. Department of Energy's own Energy Information Agency predicts that renewables will have a market share of just 5% by 2010.

FACT: A recent Solar Energy Industries Association study found that the use of renewables will double by 2010.

ALLEGATION#3: The cost of such an expanded market share for renewables will cost taxpayers, consumers and utilities only $1.9 billion, rather than $52 billion through 2010 as stated in *Energy Choices*.

FACT: In order to reduce the projected cost of expanded market share for renewables by $8.6 billion, NREL used factually incorrect data about the price of coal, the capacity utilization rate for new coal plants and the true cost of building a new coal-fired plant.

FACT: To reduce the cost of renewables by another $31.6 billion, NREL assumed (contrary to all current experience) that renewable technologies, even conventional wood burning, will experience dramatic gains in efficiency, while coal will experience *none*.

FACT: For another reduction in cost of $9.9 billion, NREL actually projects 25% less renewable development over the next 10 years than RDI's projection, and then NREL predicts 80% growth for renewables between 2005-2010, while RDI projects steady growth for renewables.

FACT: Even if NREL is correct in their calculations (which they are not), Americans will spend two ***billion*** dollars more for electricity from renewables than today's most competitive alternative over the next 15 years.

FACT:
To reduce the cost of renewables by another $31.6 billion, NREL assumed (contrary to all current experience) that renewable technologies, even conventional wood burning, will experience dramatic gains in efficiency, while coal will experience *none*.

CEED is also surprised by NREL's growth projections for individual renewable technologies. NREL is much less optimistic than RDI about the growth of solar energy, predicting 56% less growth for solar than does RDI. Instead, NREL predicts huge growth in geothermal (which is acknowledged to be a geographically limited resource) and biomass. The projected growth for biomass is particularly interesting since it is a combustion technology, and by NREL's own calculations, biomass is 33% more expensive than coal.

Further, NREL did not respond to many key RDI study findings. We believe it is only reasonable to assume by NREL's silence they must agree that:

✔ Renewables have limited ability, because of geographical and logistical constraints, to deliver electricity to the grid.

✔ Outside California, most of the electricity generated by renewables comes from combustion technologies--not wind, solar or geothermal processes.

✔ Despite government incentives and private sector subsidies, renewables cannot replace fossil fuels in the nation's generation mix.

Evidently our research on renewables touched a nerve causing the Department of Energy to spend taxpayers' dollars in preparing, printing and distributing the NREL report. Unfortunately, NREL's reply was a superficial and inaccurate response to such an important national study.

CEED is ready to debate--at any place and any time--the findings of our study and their policy implications for our states and our nation. *Energy Choices* will withstand the white light of public scrutiny. We urge close examination of RDI's detailed response to NREL's report on the following pages.

Evidently our research on renewables touched a nerve causing the Department of Energy to spend taxpayers' dollars in preparing, printing and distributing the NREL report. Unfortunately NREL's reply was a superficial and inaccurate response to such an important national study. Out of the NREL critique comes much sound and fury, but no original research or meaningful insight. We do, however, appreciate the opportunity to reengage in the debate about the role that renewables and other traditional fuels will play in America's energy future.

Sincerely,

Stephen L. Miller

Stephen L. Miller
President, The Center for Energy & Economic Development

Response to NREL's critique of *Energy Choices in a Competitive Era*

by

Resource Data International, Inc.

November, 1995

RESOURCE
INTERNATIONAL, INC.

In April 1995, Resource Data International, Inc. (RDI) released the study *Energy Choices in a Competitive Era: The Role of Renewable and Traditional Energy Resources in America's Generation Mix*. The study was commissioned by the Center for Energy and Economic Development (CEED) and its purpose was to develop a comprehensive and balanced analysis of the characteristics and relative costs of the various technologies that are today capable of delivering new electricity generating capacity to the grid. In October 1995, the National Renewable Energy Laboratory (NREL) released a paper entitled *The True Cost of Renewables: An Analytic Response to the Coal Industry's Attack on Renewable Energy*.

RDI finds that the NREL paper reinforces, rather than refutes, the major points emphasized in *Energy Choices* -- that fossil-fuel technologies are still less expensive than renewables and that renewables continue to primarily fit niche power market opportunities.

RDI welcomes debate over our assumptions and acknowledges that different analysts may well select different assumptions, but having reviewed the NREL paper, RDI stands firmly behind all of the data, assumptions and conclusions in our study. *Energy Choices* contains a lengthy sensitivity analysis in its technical appendix, and CEED has made RDI's levelized production cost model available to the public for the purpose of sharing sensitivities that may not have been provided in the study itself. In fact, RDI assisted NREL in its review of the *Energy Choices* model.

As would be expected, NREL's paper presents many cost assumptions that differ from RDI's. The following pages to this response contain RDI's comments on each of those assumptions, as well as our comments on many of the differing points of view presented in NREL's text. Despite these differences, RDI finds that the NREL paper reinforces, rather than refutes, the major points emphasized in *Energy Choices* -- that fossil-fuel technologies are still less expensive than renewables and that renewables continue to primarily fit niche power market opportunities. These are the points that utilities and regulators must consider as they plan new central generating capacity additions through the end of this decade.

1. RESPONSE TO THE CHARACTERIZATION OF *ENERGY CHOICES* AS AN "ATTACK" ON RENEWABLES

If *Energy Choices* appears to be an "attack" on renewable energy technologies, that is only because it presents a practical look at those technologies and contrasts with the promotion of those technologies as competitive and capable of wholly displacing fossil-fuels. Indeed, surveys have shown that the layperson's perceptions of the available electricity generating technologies diverge widely from reality.

To temper those perceptions, *Energy Choices* presents a primer on electric utility load profiles and the concept of plant dispatch. Using these basic concepts, the study points out that intermittent technologies (such as wind and solar) are not appropriate as baseload capacity, while coal is. Likewise, the operational characteristics of coal plants make them unsuitable for peaking positions, which are better met by natural gas (and, in some cases, wind). The study also presents a comparison of costs, location of resources, and identification of some of the environmental drawbacks to renewable technologies.

Energy Choices states that renewable energy projects will continue to be developed where they are competitive and projects that renewable generation will grow by 140% by 2010. Wind itself is projected to grow by 400%. Rather than an "attack," this projection serves more as an affirmation of the role that renewables can play.

If *Energy Choices* appears to be an "attack" on renewable energy technologies, that is only because it presents a practical look at those technologies and contrasts with the promotion of those technologies as competitive and capable of wholly displacing fossil-fuels.

2. RESPONSE TO NREL COMMENTS ON FUTURE GENERATION MIX

As stated above, *Energy Choices* projects that renewable generation will grow by 140% by 2010 and will double its share of the U.S. generation mix (increasing from 2.4% to 4.4%). This projection supports RDI's assessment that renewables will continue to play a niche role in power markets. NREL's paper suggests that renewables' share of the generation mix will be much greater than our 4.4%, but offers no quantification of what growth will actually take place.

In fact, in its report, NREL uses RDI's base case model for renewables growth between today and 2010, but is much more pessimistic than RDI about both the pace and nature of that growth. Specifically, NREL projects very slow growth in renewables between now and 2005, and then explosive growth (80% over five years) between 2005 and 2010, just to get to RDI's more aggressive renewable projection.

Further, NREL is much less optimistic than RDI about solar technologies -- RDI projects 22 billion kilowatt hours (bkWh) by 2010, but NREL projects only 9.6 bkWh (56% less). NREL projects extreme growth in geothermal (a resource all acknowledge is limited by geography and resource availability), and biomass (a combustion technology, which, to reach NREL's projections, would require extensive cultivation of forests for wood burning -- an unpopular approach among most environmentalists.) And finally, NREL projects 50% less Waste-to-Energy development than does RDI. *Energy Choices* demonstrates that our growth projection is more realistic and in-line with other forecasters. For example, the Department of Energy's Energy Information Administration (EIA) projects a renewable market share of 5% in 2010.[1] And the Solar Energy Industries

The Solar Energy Industries Association (SEIA) study entitled, *An Alternative Energy Future,* also projects that use of renewables will double by 2010—slightly less aggressive growth than RDI's projection.

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[1] See EIA's Annual Energy Outlook 1995 (AEO95), which projects an 11% market share for all renewables, including hydro. RDI's number including hydro is 10%, with hydro itself being 6%.

Association (SEIA) study entitled, *An Alternative Energy Future*, also projects that use of renewables will double by 2010 -- slightly less aggressive growth than RDI's projection.

3. Response to $52 Billion vs. $1.9 Billion Cost of Renewables

The NREL paper misses the main points of *Energy Choices* by focusing on RDI's estimate that our projected growth for renewables will cost $52 billion above today's most competitive power alternatives. NREL recalculates that estimate through a number of steps (see below) to arrive at their estimate of $1.9 billion. Even accepting the $1.9 billion number, the conclusion remains that renewable technologies are more expensive than traditional technologies. However, we disagree with NREL's calculation for the following reasons:

a. Assumptions About the Cost of New Coal Plants

1. Capital Cost

NREL states that *Energy Choices* "relies on data that overstates the cost and performance advantage of coal-fired plants." In fact, where NREL relies on ***estimates*** from the EPRI Technical Assessment Guide (TAG), RDI relies on ***actual capital cost*** figures supplied by industry vendors and engineering firms, based on actual bids and projects built over the past three years.[2]

> **In fact, NREL naively assumes no technology improvements for coal over the next fifteen years.**

Even so, RDI believes that the coal capital figures used in *Energy Choices* are conservative with respect to the latest technology innovations currently undergoing commercialization. Boiler manufacturers continue to dramatically lower costs through sourcing of off-shore components and standardized design.[3] Further, plant efficiencies continue to improve (50% heat conversion efficiencies are anticipated within the next few years, compared to today's efficiencies of about 33%). This fact is counter to NREL's basic incorrect assumption that mature coal technologies are stagnant and will experience rising costs in the future. In fact, NREL naively assumes ***no*** technology improvements for coal over the next fifteen years.

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[2] Duke/Flour Daniel and Ahlstrom Pyropower.

2. *Capacity Factor Assumptions*

For plant operation, NREL uses the standard EPRI TAG capacity factor figure of 65% and cites the average U.S. coal plant annual capacity figures of 60%. RDI, on the other hand, uses the average capacity factor for the top 50 U.S. coal plants, which is 80%.[4] The selection of the top 50 plants is by far the more defensible method for estimating new coal plant performance for two reasons: (1) it removes old coal plants that are held in reserve or intermediate dispatch positions for economic reasons,[5] and (2) a plant developer would base its proformas on optimum plant performance, rather than average performance for all plants consuming a similar fuel.

An analogy best illustrates the flaw in NREL's assumption. If one were asked to estimate the average gas mileage of 1997 Chevrolets, one would ***not*** use the average gas mileage for all vintage Chevrolets built since 1940, but rather would rely on the gas mileage of the latest Chevrolet fleet.

3. *Coal Prices*

As for coal costs, RDI used the coal price forecast available in our annual publication, *Outlook for Coal and Competing Fuels*, which is sold to the general public. This forecast depicts RDI's projection of ***open market*** prices for coal -- i.e., the prices at which coal is bought and sold on the open market. In its calculations, NREL uses the EIA coal price forecast, which depicts the government's projection of ***average*** contract and spot prices. This is a crucial distinction, since the EIA forecast includes prices for vintage, long-term contracts, including above-market term contracts (see Response to NREL Use of Coal Contract Stranded Investments below).[6] As such, NREL's use of the EIA forecast is naive and wholly inappropriate, given that utility coal buyers today employ coal contracting strategies that preclude above-market pricing.

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[3] RDI's industry contacts claim that costs are dropping below $900 megawatt. versus our assumption of $1,000/megawatt (adjusted to $956 in 1993 dollars) in *Energy Choices* and NREL's assumption of $1,195/megawatt (not clear what year these dollars represent).

[4] See Technical Appendix page 5 in *Energy Choices*.

[5] A coal plant of 1940s or 1950s vintage can hardly be used as a benchmark for the performance of a 1995 vintage coal plant.

Again, an analogy helps to demonstrate the flaw in NREL's understanding of how coal markets work. If one were buying a new house and trying to estimate the mortgage rate, one would ***not*** use the average mortgage rate over the past 20 years, but rather would use the ***actual*** mortgage rates being quoted by lenders in today's market.

A graph of previous EIA forecasts versus actual spot market prices is attached to demonstrate the inflationary effect of NREL's assumptions on coal plant costs.

Combined, all of NREL's above-stated changes in the cost of a new coal plant inaccurately reduce the projected costs of market share for renewables by $8.6 billion.

b. Renewable Technology Cost Assumptions

NREL states that *Energy Choices* "employs unjustifiably high cost estimates for renewable energy technologies and assumes no improvement in technology costs and performance."

1. Capital and Operating Costs for Renewables

On the point of assuming high cost estimates, RDI notes (ironically) that our cost assumptions came from the EPRI TAG, which NREL found to be authoritative as a reference for coal plants. However, unlike NREL, RDI turned to the EPRI TAG only after renewable technology vendors failed to provide us with their own "real world" numbers.[7] To compensate, we put aside our more aggressive coal estimates and used conservative figures as documented in the study.[8] Even so, the differences between RDI's assumptions and NREL's assumptions about the current levelized costs of renewables are virtually insignificant in our findings.

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[6] RDI telephone interview with EIA, October 18, 1995.

2. *Improvements in technology costs and performance.*

It was beyond the scope of RDI's study to engage in a projection of improvements in technology costs for any of the technologies examined (fossil or renewable). Therefore, we held all costs constant into the future, rather than speculating on relative changes. The fact is that over the past ten years, advances in efficiencies and overall technology/fuel costs for fossils have outpaced those of renewables.

However, if NREL had simply assumed that fossil-burning technology improvements would at least keep pace with their assumptions about wood-burning technology improvements, their projected relative cost savings for renewables would plummet.

Energy Choices is about the relative costs of generating technologies that are available today. As for our $52 billion calculation, we clearly stated that this number was "above *today's* most competitive power alternative" [emphasis added].[9] Nevertheless, RDI stands by that calculation for the following reasons: (1) we anticipate that fossil technologies will continue to keep pace with the cost improvements of renewables; and (2) the increasingly competitive technologies are still built upon today's cost differentials, with the lower cost designs representing a smaller portion of a technology's total installed capacity toward the end of our projected 15-year forecast.

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[7] RDI contacted a number of wind, solar, and geothermal companies for information. We also requested the latest information from DOE and NREL, both of which declined on the grounds that the information in question was undergoing peer review.

[8] Although Duke/Flour Daniel provided coal capital costs in the $800-$900/megawatt range, RDI used $1,000/megawatt (adjusted to $956/megawatt in 1993 dollars).

[9] *Energy Choices* Summary of Key Findings.

NREL's approach is inherently biased since it assumes dramatic improvements in renewables and a crashing halt to any improvements in fossil technologies. However, if NREL had simply assumed that fossil-burning technology improvements would at least keep pace with their assumptions about wood-burning technology improvements, their projected relative cost savings for renewables would plummet .

The above alterations of RDI's model, allow NREL to erroneously reduce RDI's estimated cost of renewables by another $31.6 billion.

c. *Renewable Technology Market Share*

NREL asserts that *Energy Choices* assumes "a fixed market share for renewable energy technologies," while NREL "assumes a more orderly development path." In fact, RDI's assumptions are built upon current development plans supplied by each respective renewable technology industry group. For example, we used an American Wind Energy Association (AWEA) list of new wind projects under various stages of development to form the basis of our base wind forecast and adopted AWEA's target goals for our best case (for renewables) scenario. We also incorporated assumptions published by geothermal experts in such periodicals as the *Geothermal Bulletin*. In short, rather than make mathematical assumptions, RDI chose to look at what the industry is actually doing and planning.

In fact, NREL's "more orderly development path" significantly reduces the development of renewables below RDI's estimates between now and 2005. Specifically, NREL projects very slow growth in renewables between now and 2005, and then explosive growth (80% over five years) between 2005 and 2010. By artificially shoving the lion's share of renewable growth into the last five years of the forecast period, NREL reduces the ***cumulative*** cost of reaching the 4% market share figure by $9.9 billion. But what NREL fails to point out in their study is that these cost savings are gained through a significant reduction in RDI's projection of the amount of "renewable kilowatt hours" produced over the study period -- i.e., a reduction of 243 billion kilowatt hours of renewable production.

Further, as stated earlier, NREL is much less optimistic than RDI about solar technologies -- RDI projects 22 bkWh by 2010, but NREL projects only 9.6 bkWh (56% less) -- and about Waste-to-Energy (50% less than RDI).

In conclusion, NREL reduces the $52 billion figure presented in *Energy Choices* to $1.9 billion through a number of debatable assumptions and misinterpretations of RDI's work.

4. RESPONSE TO THE SUBSIDY ISSUE

Overall, analysis of direct subsidies is outside the scope of *Energy Choices*. The study held to a cost analysis of the various generating technologies given current cost structures and current levels of public support. While our intention in calculating the $52 billion cost for installing additional renewable capacity was to demonstrate the cost differentials between renewables and traditional technologies, we acknowledge that the implication that additional costs will be borne by the public opened the door to a discussion of subsidies.

The terms of the federal contribution require that the projects *repay* the Clean Coal Technology investment upon commercialization. As such, the CCT program is better characterized as a loan program than as a blanket subsidy. Conversely, subsidies for renewables do not require a payback.

NREL chose to walk through that door by focusing on direct federal subsidies to the coal industry. Their argument becomes that all industries should be entitled to like levels of subsidization. In pursuing this argument, NREL correctly focuses on the federal government's Clean Coal Technology (CCT) program as a point of subsidy comparison. In doing so, NREL recognizes that federal dollars spent for mining regulation and management (such as the Mine Safety & Health Administration and the Bureau of

Land Management) tend to increase coal costs and are not market-based subsidies.[10]

Conversely, the CCT program is intended to provide market support for coal demonstration projects, much like tax credits in the Energy Policy Act of 1992 provide market support for wind and certain biomass projects. In other words, these subsidies reduce.the difference in costs between the CCT and renewable projects and the cost that power markets are able to bear -- but here the similarities stop.

Of the total $7.2 billion invested in the CCT program, over two-thirds, or $4.8 billion, are being contributed by private companies and a few state governments. The federal government, itself, is only investing $2.3 billion.[11] Furthermore, the terms of the federal contribution require that the projects *repay* the Clean Coal Technology investment upon commercialization. As such, the CCT program is better characterized as a loan program than as a blanket subsidy. Conversely, subsidies for renewables do not require a payback.

RDI notes this difference as a point of clarification. We do not take a position with regard to any subsidy that is currently in place.

5. RESPONSE TO NREL'S USE OF COAL CONTRACT STRANDED INVESTMENTS

NREL cites an RDI presentation to the National Association of Regulatory Utility Commissioners (NARUC) given July 25, 1995 where RDI identified $14.8 billion in utility stranded investments related to above-market, long-term coal contracts. NREL uses this statistic to imply coal industry subsidization.

As an initial response, RDI notes that stranded investments in existing coal contracts are not relevant to a discussion of the costs of new coal plants. The contracting philosophies of utility fuel buyers have evolved to the point where new contracts bear little risk of becoming stranded in the future. Mechanisms such as frequent market price reopeners are just one technique now used to prevent high contract prices.

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[10] In fact, the BLM earns money for the government through coal mining royalty receipts.

[11] DOE/FE-0291 (Revised) *Clean Coal Technology: The Investment Pays Off*, July 1995

Furthermore, stranded coal contracts did not arise because of a government subsidy or mandate. Rather, they are long-term (10 to 20 year) contracts signed by utilities, with state public utility commission approval, at a time when the utilities perceived the need to secure a long-term fuel supply at what they believed to be fair market price. The structure of the contracts tended to insulate pricing from market dynamics, which seemed to be a prudent strategy in the volatile energy markets of the late 1970s and early 1980s. However, since the mid-1980's, coal prices have continuously declined, leaving the insulated contract prices above market.

Presently, RDI is providing advice to coal suppliers, railroads, and electric utilities on how to renegotiate many of these above-market contracts to the benefit of all participants.

6. RESPONSE TO RELIABILITY ISSUES

NREL suggests that *Energy Choices* depicts renewable technologies as "inherently unreliable." This is untrue. *Energy Choices* clearly states the availability of wind turbines is now in excess of 90% and that geothermal units achieve 90% annual capacity factors.

Energy Choices does, however, discuss the intermittent nature of solar and wind technologies that results in an annual capacity factor of 20%-30%. Note that NREL provides these same figures in its paper. There is no disagreement here. Dispatchability and load matching determine whether those capacity factors are suitable to a particular utility system. Although PG&E has been able to fit wind into 7% of its system load, that does not mean that Philadelphia Electric would be able to do the same.[12] For this reason, *Energy Choices* characterizes renewables as *niche* applications.

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[12] In its paper, NREL appears to compare PG&E's 7% load contribution to RDI's U.S. generation mix projection of 4% by stating that the PG&E result is "far above the contributions examined in [*Energy Choices*]." Obviously, there is no basis for making a comparison between the national generation mix and one specific utility

7. RESPONSE TO COMPETITION ISSUES

NREL states that the renewable energy industry "welcomes truly open and fair competition." RDI has heard this same comment from wind power developers. On the one hand, truly open competition would be a major set-back to renewable project development because it would immediately withdraw state mandates and the federal 1.5¢/kilowatt-hour tax credit.[13]

On the other hand, the renewables industry recognizes the power of "green marketing," which, if exercised under open competition, would allow individual ratepayers to pay an extra charge on their electricity bill in order to buy "green electricity." This is an innovative idea that may come to fruition at some point in the future. Yet, today it is just a concept that has not been fully researched and whose potential is unknown. This sentiment of uncertainty is echoed by the NREL paper.

Truly open competition would be a major set-back to renewable project development because it would immediately withdraw state mandates and the federal 1.5¢/kilowatt-hour tax credit.

Finally, RDI again notes that the NREL paper supports our contention that renewables are best suited to niche markets. This follows from the concept of green marketing, which is best described as *niche* marketing.

8. RESPONSE TO ENVIRONMENTAL ISSUES

Energy Choices defines its scope of analysis to the relative costs of the various generating technologies, given current cost structures and current levels of public support. Environmental externalities are included in these costs with regard to coal plant sulfur dioxide, nitrogen oxide, and particulate emissions, as well as mine reclamation and land management costs. As such, *NREL's statement that "the prospective cleanup costs of fossil-fuel-based plants are never considered up front when generation investment decisions are made" is plainly false.*

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[13] This tax credit accounts for more than 20% of the production cost at qualifying projects.

However, the prospective clean-up costs of renewable plants are never considered up-front. Instead, the NREL paper conveniently ignores the adverse environmental impacts of renewables, choosing instead to reinforce the popularly held belief that coal plants are dirty polluters. *Energy Choices* starts from the assumption that the public sees coal as severely impacting the environment and renewables as having no impact.

For that reason, *Energy Choices* points out that combustion technologies constitute over 70% of all existing renewable capacity, that wind turbines impact raptor populations, that geothermal technologies degrade hydrothermal resources, that solar cell manufacturing processes may use harmful chemicals, and that municipal solid waste incinerators are key sources of hazardous air pollutants.

Energy Choices *points out that combustion technologies constitute over 70% of all existing renewable capacity, that wind turbines impact raptor populations, that geothermal technologies degrade hydrothermal resources, that solar cell manufacturing processes may use harmful chemicals, and that municipal solid waste incinerators are key sources of hazardous air pollutants.*

Our study then puts forth a side to coal that is little known -- that U.S. coal generation *doubled* from 1970 to 1990, while emissions of sulfur dioxide, nitrogen oxide, and particulates have remained relatively constant. This is due, in part, to regulations for new plants set forth under the 1970 Clean Air Act and its 1978 amendments. As a result of this legislation, new coal plants today emit only 2%-3% of the sulfur dioxide, nitrogen oxide, and particulates found in 1970's vintage coal plants.

This success story is also partly due to the development of low sulfur coal reserves in the western United States. Since the mid-1980's, coal companies (anticipating further clean air legislation and attracted by favorable mining economics) have steadily been redeploying their assets to western fields. A number of these companies actively lobbied in support of the Clean Air Act Amendments of 1990 (CAAA).

The passage of the CAAA prompted utility buyers to test burn the lower sulfur western coal. Many soon found that favorable economics unrelated to sulfur content justified a permanent switch to that supply region. As a result, two-thirds of all CAAA plants affected in Phase I (the period 1995-1999) are vastly overcomplying with their emission limitations, while at the same time saving significant sums of money. This fact contradicts NREL's assertion that the CAAA clean-up of coal plants will cost ratepayers in excess of $4 billion.

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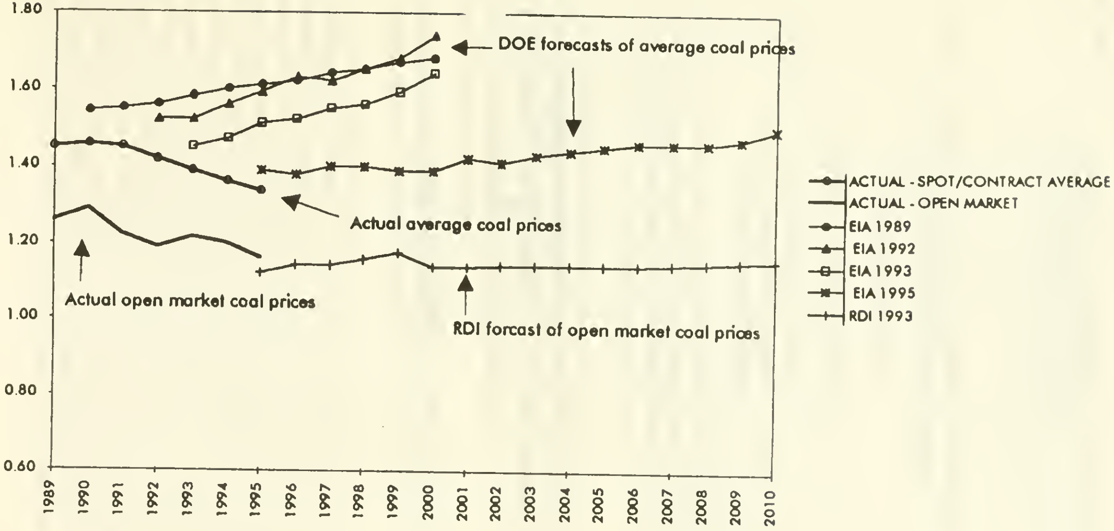
FORCAST COMPARISON

DELIVERED PRICE TO ELECTRIC UTILITIES FOR STEAM COAL



RESOURCE DATA INTERNATIONAL, INC.

The Honorable Christine A. Ervin
Assistant Secretary for Energy Efficiency and Renewable Energy
U.S. Department of Energy

Answers to Followup Questions

HEARING OF THE SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

on

The Department of Energy's FY 1997 Budget Requests for Energy Efficiency and Renewable Energy and Fossil Energy Programs

Wednesday, April 17, 1996

Followup Questions Submitted to

Hon. Christine A. Ervin
Assistant Secretary for Energy Efficiency and Renewable Energy
U.S. Department of Energy

Q1. On page 2 of your testimony, you stated: "Prices for energy delivered by renewable energy technologies have dropped by orders of magnitude, from 90 cents per kwh to 20 cents in 1995, for photovoltaics; from 40 cents per kwh to 5-6 cents in 1995, for wind; from 9 cents per kwh to 5 cents for geothermal energy."

However, according to Dr. McMahan's testimony, his study of the comparative levelized costs, including subsidies, of renewable electricity generation found 27.4 cents per kwh for photovoltaics and 8 cents for geothermal energy.

How do you explain the disparity and how much would the delivered prices be in the absence of taxpayer subsidies?

A1. Our estimates for the recent prices of electricity generated by photovoltaics and geothermal energy are based on available data on actual projects and utility purchases.

The price of geothermal electric power is highly variable due to differences in geology and resource temperature and pressure from site to site. However, based on aggregated cost estimates released by the Geothermal Energy Association (GEA) in 1993, a price of 5 cents per kilowatt-hour (kWh) represents the average for U.S. dry steam plants operating on the highest quality resources. Dry steam plants represent around 55% of the current U.S. geothermal operating capacity. Other sources of price information include the Biennial Resource Plan Update auction in California (1994), which resulted in geothermal contracts with a bid price of 5.6 cents per kWh, and a 1992 Form 10-K filing by OESI Power Corporation, which indicated average prices of 4.76 cents per kWh and 5.65 cents per kWh for two 30-year power purchase agreements. The latter prices assume 40 on-peak hours per week and capacity factors of 90% for one contract and 80% for the other. These U.S. prices for electricity from geothermal energy are indirectly subsidized through the 10% geothermal energy tax credit. Without the tax credit, the price for electricity from geothermal resources would increase roughly 8% to about 5.4 cents per kWh.

The cost of electricity from photovoltaics, like geothermal, is dependent on the quality of the resource and will vary from site to site. Our estimate is based primarily on the experience of the Sacramento Municipal Utility District (SMUD). As a result of recent bids it had received for photovoltaic systems, SMUD has put its 30-year cost of electricity for residential/commercial PV systems at 19 cents per kWh. The quoted photovoltaics costs are without Federal subsidies.

We do not know how Dr. McMahan obtained his numbers or nor the assumptions underlying them.

Q2. On page 2 of your testimony, you also stated: ". . . our renewable energy industries are poised to capture burgeoning domestic and international markets."

However, according to the reference case projections to 2015 contained in Table A8 on pages 94 and 95 of the Energy Information Administration (EIA) Annual Energy Outlook 1996 renewable sources will generate only 8.8% of our electricity in 2015–a nearly 1% decrease from the 1995 level of 9.7%.

Q2a. Where is this "burgeoning" domestic market for renewable energy, and what does this portend for the international arena?

A2a. The expected growth in the domestic market for electricity is not as dramatic as the growth expected in the international market. According to the Energy Information Administration, the domestic market for electric capacity additions between 1995 and 2015 is estimated to be about 243 gigawatts. On the other hand, EIA predicts that the consumption of electricity in just the Asian countries which are not members of the Organization for Economic Cooperation and Development will increase from 1,733 billion kilowatt-hours in 1995 to 4,781 billion kilowatt-hours in 2015. This increase of more than 3,000 billion kilowatt-hours is greater than the total amount of electricity consumed in the U.S. in 1995, representing a total installed capacity of more than 780 GW.

Renewable energy will capture a significant portion of this future market with or without U.S. technology. The issue is whether in the long term the United States will be an importer or an exporter of these technologies; whether we will have a renewable energy industry or not. The international development of wind power is an example of how more aggressive investment by European nations is affecting the United States' technological status. Already Europe, with 2,489 MW of wind power installed in 1995, has surpassed the United States. According to the International Energy Agency, installed wind power in Germany alone increased from 643 MW in 1994 to 1,137 MW in 1995. In comparison, installed wind capacity in the United States grew by only 140 MW–from 1,630 MW to 1,770 MW–in the same period. Italy has approved projects for 300 MW of wind power and has plans for another 1,000 MW in the next 5 years. A more telling comparison is that while almost 50% of the installed wind capacity in the United States represents technology imported from Europe, U.S. technology accounts for only 5% or less of the installed capacity in Europe. A similar story can be told for the tremendous emerging market represented by the developing nations. India, for example, added 430 MW of wind power in 1995, more than 3 times the U.S. figure, and will have a somewhat larger increase in 1996. In India, 95% of the installed capacity is Danish technology.

Q2b. Alternatively, if there is indeed a "burgeoning" domestic and international market, why do the taxpayers–through DOE–need to continue to subsidize the players? Where is the alleged "market failure" that might be used to justify such subsidies?

A2b. The U.S. renewable energy industries will capture a significant portion of this expanding market only if further technology progress, together with domestic and international sales sufficient to maintain a healthy U.S. industry, enable us to continue the significant reductions in the cost of electricity from these technologies that we have experienced in the past 10 years. Utility restructuring represents both opportunities and challenges for the renewable energy industry. Customer choice represents a market opportunity. But in the near-term, uncertainties facing utilities both with regard to how restructuring will be implemented across the nation, as well as with regard to the utilities' own strategies for coping with these changes, have killed a number of renewable projects and have dampened prospects for future opportunities. In addition, the well-known phenomenon of lock-in penalizes renewable energy technologies. Lock-in arises from the self-reinforcing nature of technology choice, which makes it difficult for the newer renewable technologies to capture significant market share in a market already dominated by fossil fuel technologies. In addition to institutional inertia, it is also more burdensome to finance power projects employing these newer technologies.

Q3. On page 2 of your testimony, you also stated: ". . . companies manufacturing energy efficiency and pollution prevention technologies and developing renewable energy technologies can compete in the emerging trillion dollar global market for energy and environmental technologies, representing the potential to return millions of dollars in sales to our domestic economy."

If there is a trillion dollar global market for energy and environmental technologies, why do the taxpayers–through DOE–need to continue to subsidize the players? Where is the alleged "market failure," that might be used to justify such subsidies?

A3. First, the trillion dollar market is one that is projected to evolve over the next 10-15 years as the underdeveloped countries continue their industrialization process. Huge potential exists for electrification in these parts of the world where vast populations live without any electricity. Second, in efforts to capture these markets, U.S. companies manufacturing energy efficiency and pollution prevention technologies and developing renewable energy technologies face competition not only from other technologies, but also from non-U.S. firms which receive substantial support from their respective governments. Several

European countries allow one-year accelerated depreciation or provide other subsidies in order to nurture their domestic industry. Furthermore, the use of tied grants and concessional financing has allowed European manufacturers to establish themselves in emerging markets like China, Egypt and India.

Q4. It is our understanding that the Department commissioned a report by the National Renewable Energy Laboratory (NREL) entitled "The True Cost of Renewables: An Analytical Response to the Coal Industry's Attack on Renewable Energy," which was published in October, 1995 (NREL/TOP-462-20032).

Q4a. Please provide a copy of this report.

A4a. A copy of the report is provided.

Q4b. Please identify who commissioned this report.

A4b. The Office of Energy Efficiency and Renewable Energy commissioned the report.

Q4c. Please provide a detailed accounting of the cost of preparing this report.

A4c. The cost of preparing the report was $25,234; $23,212 for preparation of the manuscript, including data gathering and technical writing; and $2,022 for editing, layout and preparation of copy for publication.

NREL/TP-462-20032 • UC Category 1320 • DE95013114

The True Cost of Renewables:

An Analytic Response to the Coal Industry's Attack on Renewable Energy

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Preface

One intended result of federal investments in renewable energy research and development (R&D) programs is the adoption and use of renewable energy technologies in the energy marketplace. Insights into the nature of energy markets can help to assure that the technologies being developed are compatible with these markets.

In April 1995, the Center for Energy and Economic Development (CEED), a coal industry lobbying group, issued a report critical of the role that renewable energy technologies can play in future power sector markets. Both the National Renewable Energy Laboratory (NREL) and the U.S. Department of Energy (DOE) felt that it was important to respond to the CEED report by examining its basic assumptions regarding renewable energy and fossil-fuel-based technologies and future power markets. This report documents the NREL analysis that refutes many of the CEED report's key findings.

NREL's Analytic Studies Division (ASD) supports the long-range planning of the overall federal renewable energy R&D program, both at NREL and DOE, by conducting analyses on aspects of energy market competition that are relevant to the present and future deployment of renewable energy technologies. ASD reports on these efforts to DOE and NREL managers, as well as external utility sector stakeholders, to enhance their awareness of competitive and institutional factors that may affect the successful deployment of renewable energy technologies in the marketplace.

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Introduction

> . . . *a modest growth path of renewable resource development would essentially cost the nation little more than projected electricity market costs for coal-fired generation. . . .*

In April 1995, the Center for Energy and Economic Development (CEED), an umbrella organization of pro-coal interests, released a report entitled *Energy Choices in a Competitive Era: The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix.* The report purports to show that a very modest growth in the use of renewable energy in the U.S. power sector would entail unaffordable costs for the nation's electricity ratepayers.

The National Renewable Energy Laboratory (NREL) was commissioned by the U.S. Department of Energy (DOE) to review the assumptions contained in the report, which was prepared for CEED by Resource Data International, Inc. (RDI). The NREL analysis finds that the conclusions of the CEED/RDI study are based on faulty data and assumptions regarding the comparative economics of coal and renewable energy development. After correcting these errors, NREL finds that a modest growth path of renewable resource development would essentially cost the nation little more than projected electricity market costs for coal-fired generation, even before considering the environmental benefits that would accompany this development.

The True Cost of Renewables

> . . . *because renewable energy technologies will become more, not less, cost competitive, nonhydro renewables could . . . supply a much larger fraction of the future power market than the 4% assumed by CEED/RDI.*

The CEED/RDI study claims that a modest increase in the contribution of nonhydro renewable energy sources, from 2% of total electricity supply today to 4% in 2010, will cost the nation $52 billion "above today's most competitive power alternatives." NREL estimates that the extra cost of renewables development would be $1.9 billion over 15 years, or an average of just more than $100 million annually — less than one-tenth of 1% of the total annual revenue of the U.S. electric utility industry. In fact, the NREL analysis shows that certain renewable energy technologies, such as geothermal and wind, are projected to become *more economic* than coal during this period.

Why the big difference? First, the CEED/RDI analysis relies on data that overstate the cost and performance advantages of coal-fired plants. The NREL analysis used coal data from the Electric Power Research Institute (EPRI), the national research and development (R&D) organization for the electric utility industry, and from the U.S. Energy Information Administration (EIA), the statistical arm of DOE. This change alone reduces the CEED/RDI renewables cost by $8.6 billion.

Second, the CEED/RDI analysis employs unjustifiably high cost estimates for renewable energy technologies and assumes no improvement in technology costs and performance throughout the 15-year analysis period. This assumption is contrary to recent market experience, which has seen several utilities contract for cost-effective renewable energy power. In addition, this assumption runs counter to the last 15 years of history, which has witnessed dramatic improvement in renewable energy technology costs and performance. Many energy analysts expect these improvements to continue.[1] For its analysis, NREL substituted renewable energy cost data from DOE, which are more representative of current market costs and which account for expected future technology improvements. This substitution accounts for a further reduction of $31.6 billion from the CEED/RDI estimate.

Finally, the CEED/RDI analysis assumes a fixed market share for renewable energy technologies. It does not consider comparative economics or the ability of renewable energy industries to supply the market. The NREL analysis assumes a more orderly development path for the renewables industries. This final difference reduces the CEED/RDI estimate by another $9.9 billion, leaving a total "above-market" cost estimate of only $1.9 billion over the next 15 years. Furthermore, because renewable energy technologies will become more, not less, cost competitive, nonhydro renewables could be reasonably expected to supply a much larger fraction of the future power market than the 4% assumed by CEED/RDI.

Energy Subsidies

The CEED/RDI study implies that renewable energy technologies can only be competitive with massive public subsidies, stating that "advocates for renewable energy technologies are increasingly heading to public policy forums as they fail to make their case in the open market" (page 16).

> *"because the great bulk of incentives support mature fossil fuel and nuclear equipment, the existing subsidy structure markedly distorts the marketplace . . . away from renewables."*
> —Congressional Research Service

However, what CEED/RDI fail to note is that coal and other fossil fuels historically have been and continue to be the recipients of massive public subsidies. A recent paper by the Congressional Research Service (CRS) summarizes the findings of several energy subsidy studies, including a 1992 study by DOE's EIA.[2] These studies have consistently found that public subsidies given to fossil fuels far outweigh incentives available for renewables development. Indeed, CRS notes that the most recent of these analyses found that "because the great bulk of incentives support mature fossil and nuclear equipment, the existing subsidy structure markedly distorts the marketplace for energy in a direction away from renewables."

Most recently, the federal government has contributed nearly **$3 billion** to the development of new coal-burning technologies through the Clean Coal Technology Program, while the renewable energy industry is today fighting to maintain a $300 million annual federal R&D budget for all renewable energy technologies combined.[3] And RDI itself, in another recent analysis, estimates that ratepayers nationwide will incur costs of **$14.8 billion** because of above-market, long-term coal contracts between electric utilities and coal producers.[4]

Environmental Impacts

While CEED/RDI expend great effort to ascribe negative environmental impacts to renewables, they conveniently ignore the costly environmental impacts associated with the combustion of fossil fuels. For example, because of fossil-fuel-based emissions of sulfur dioxide and nitrogen oxides, electricity ratepayers will be required to pay **$4 billion or more per year** to clean up emissions under the Clean Air Act Amendments of 1990.[5] The specter of additional emissions control requirements (e.g., for control of air toxics and fine particulates, not to mention carbon dioxide), as well as environmental taxes, potentially creates additional cost burdens.

The prospective environmental cleanup costs of fossil-fuel-based plants are never considered up front when generation investment decisions are made. . . .

The prospective environmental cleanup costs of fossil-fuel-based plants are never considered up front when generation investment decisions are made; only later are ratepayers presented with these costs.

The Reliability of Renewable Energy Systems

To further discredit renewables, the CEED/RDI report states that many renewable energy systems are inherently unreliable. In fact, using traditional utility reliability criteria as a gauge, the reliability of renewables projects is generally comparable to that of conventional utility generating plants. For example, the availability of newer wind plants has improved to 95% or greater on average.[6] And photovoltaics systems are highly valued in remote applications specifically for their high reliability compared with the reliability of diesel generation and stand-alone battery systems.

. . . the reliability of renewables projects is generally comparable to that of conventional utility generating plants.

CEED/RDI point to the capacity factors and dispatchability of renewable projects as reliability issues. However, the majority of renewable technologies can operate in base load or are otherwise dispatchable; geothermal units can have capacity factors greater than 90%. For comparison, the average capacity factor for all operating coal-fired power plants in the United States was 60% from 1990 to 1994.[7] Solar- and wind-based projects, without storage, typically have capacity factors of 20% to 30% because they operate only when the sun shines or the wind blows.

However, the plant capacity factor is not as important as whether the plant generates its predicted output, that is, the output level upon which the economic decision to build the plant was based.

Also, utility plants are dispatched based on production costs, and because many renewables have low production costs, renewables tend to be dispatched whenever the output is available to displace the power produced from units with higher production costs.

When power from intermittent resources is not available, other generators on the system must be called upon to supply the power. At low penetration levels, this situation is much like the normal utility system response to load fluctuations. At higher penetration levels, a utility might have to provide additional dispatchable capacity to compensate for both normal load fluctuations and the output variations of intermittent generators. A recent NREL review of this topic suggests that intermittent generation levels of at least 10% can be accommodated with no adverse system impacts.[8] Already today, wind generation provides up to 7% of the system load, and has supplied about 5% during peak hours, on the Pacific Gas and Electric system with no adverse effects.[9] These intermittent penetration levels are far above the contributions examined in the CEED/RDI study. In fact, research shows that intermittent penetration levels above 10% are also entirely feasible, with any technical limits being a function of the specific utility system characteristics.[10]

The Impact of Electricity Competition

Finally, CEED and RDI state that with "open and direct competition" in electricity markets, renewable energy use is likely to decline because it will be priced out of the market. On the contrary, the renewable energy industry welcomes truly open and fair competition as a boon to renewables development.[11] This is because true competition will provide electricity customers with the ability to choose from an expanded number of electricity suppliers offering alternative services, ones that will include renewables. This situation is akin to shopping at a supermarket where customers base their purchases, in part, on product differentiation and perceived value. A large segment of the American public has consistently supported greater development of renewable energy sources, and utility surveys are also revealing customer preferences for renewables.[12] At the same time, a growing market will ensure continued improvement in the economics of renewable energy technologies.

> *. . . the renewable energy industry welcomes truly open and fair competition as a boon to renewables development.*

However, the electric industry is just now beginning its experiment with more competitive market structures. In addition, the existing system of energy subsidies will continue to distort energy market decisions. To the extent that truly fair and competitive markets cannot be obtained, public policies and regulation may still be required to assure that the public interest is factored into market outcomes. And even in a perfectly competitive market, market failures, such as accounting for the uncosted environmental impacts of different energy resources and assuring adequate provision of public goods, will continue to exist. A properly functioning competitive market should provide ample development opportunities for renewables. We won't really know until effective market tests are performed.

Endnotes

1. See, for example, the discussion on renewable energy in DOE's recent National Energy Policy Plan, which notes that "During the last 15 years, intensive work by industry and the Department of Energy's national laboratories has steadily increased the reliability of renewables energy systems while dramatically lowering their costs. These systems are gradually becoming commercially competitive with conventional power sources" (*Sustainable Energy Strategy: Clean and Secure Energy for a Competitive Economy*, July 1995, page 44). An analysis of energy futures performed by Shell International notes that renewables costs will continue to fall as production increases. Thus, the key question for renewables is not whether costs will be lowered but "the speed at which market opportunities will appear, to enable renewables to move down their cost curves" (E.J. Grunwald, "Energy in the Long Term," Shell International Petroleum Co. Ltd, undated). And even the CEED/RDI report acknowledges that "renewable energy has made important advances in lowering costs" (page 2-5).

2. F. Sissine, "Renewable Energy: A New National Commitment?" Congressional Research Service, January 5, 1995.

3. U.S. General Accounting Office, *Ways to Strengthen Controls Over Clean Coal Technology Project Costs*, GAO/RCED-93-104, March 1993.

4. Presentation by Thomas Feiler, RDI, to the National Association of Regulatory Utility Commissioners, July 25, 1995.

5. M. Hoske, "Phase I Compliance Plans Emphasize Flexibility," *Electric Light & Power*, August 1993.

6. C. Weinberg, "Wind Energy and the Electric Utility Industry," *Proceedings of Windpower '90*, American Wind Energy Association, 1990.

7. North American Electric Reliability Council, *Generating Unit Statistics 1990-1994*, June 1995.

8. Y. Wan and B. Parsons, *Factors Relevant to Utility Integration of Intermittent Renewable Technologies*, National Renewable Energy Laboratory, NREL/TP-463-4953, August 1993.

9. D. Smith and M. Ilyin, "Wind Energy Evaluation by PG&E," *Proceedings of the Ninth ASME Wind Energy Symposium*, 1990.

10. Wan and Parsons, *Op Cit.*

11. Edwin Mansfield, in his classic microeconomics textbook (*Microeconomics: Theory and Applications*, Third Edition, W.W. Norton and Company), describes the four conditions that define the model of a perfectly competitive market:
    (1) The product of any one seller must be the same as the product of any other seller;
    (2) Each participant in the market, whether buyer or seller, must be so small, in relation to

the entire market, that it cannot by itself affect the market price of the product;
(3) All resources must be completely mobile; each resource must be able to enter and leave the market, and switch from one use to another, very readily; and
(4) Consumers, firms, and resource owners must have perfect knowledge of the relevant economic and technological data.

12. See, for example, B. Farhar, *Trends in Public Perceptions and Preferences on Energy and Environmental Policy*, National Renewable Energy Laboratory, NREL/TP-461-4857, February 1993 and D. Moskovitz, "'Green Pricing': Customer Choice Moves Beyond IRP," *The Electricity Journal*, October 1993.

Appendix

NREL Calculation of National Renewable Energy Deployment Costs

This appendix documents the key assumptions adopted in recalculating the costs of continued renewables deployment as presented in the CEED/RDI report. These assumptions deal with the cost and performance attributes of coal-fired and renewable-energy-based generation, as well as the rate at which different renewable energy technologies penetrate the electricity supply market.

The RDI Base Case

To arrive at the $52 billion cost estimate for its base case renewables deployment, RDI calculates the difference between the levelized generation cost for a pulverized coal-fired plant, considered to be the lowest-cost generation option, and the weighted average cost of a mix of nonhydro renewables technologies. The renewables technologies are differentiated by those that involve combustion processes (biomass and waste to energy [WTE]) and those that are "naturally occurring" (geothermal, photovoltaics, solar thermal, and wind). RDI assumes that nonhydro renewable energy generation will grow from 75 billion kWh in 1995 to 180 billion kWh in 2010 or from 2.32% to 4.49% of the total U.S. electricity generation by 2010. The annual increase in renewable energy generation, for both combustion and noncombustion sources, is multiplied by the RDI-calculated cost differential to obtain an annual cost difference. The sum of these annual cost differences yields the aggregate $52 billion cost estimate (Table 1).

Although the CEED/RDI report states that the base case levelized cost for a new coal plant is 3.8¢/kWh (e.g., Table 4-1 on page 4-4), RDI assumes a levelized coal generation cost of 4.20¢/kWh for the base case calculation in its spreadsheet model (available from CEED). NREL was able to replicate the RDI results using this higher value.

Table 1. RDI Base Case Scenario

	Levelized Cost of Energy (¢/kWh)							Weighted Price Difference (¢/kWh)		Forecast (billion kWh)		Annual Growth (billion kWh)		Cost Difference (billion $)		
Year	Coal	WTE	Biomass	Wind	Geothermal	PV	Solar Thermal	Combust.	Other	Combust.	Other	Combust.	Other	Combust.	Other	Total
1995	4.2	9.3	11.6	6.8	8.6	27.4	21.0	6.3	7.7	54	21					
1996	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	57	23	3	2	0.2	0.1	0.3
1997	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	59	25	3	2	0.3	0.3	0.6
1998	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	62	26	3	2	0.6	0.4	0.9
1999	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	64	28	3	2	0.7	0.6	1.2
2000	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	67	30	3	2	0.8	0.7	1.6
2001	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	71	34	4	4	1.1	1.0	2.1
2002	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	75	38	4	4	1.3	1.3	2.7
2003	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	79	43	4	4	1.6	1.7	3.2
2004	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	83	47	4	4	1.8	2.0	3.8
2005	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	87	51	4	4	2.1	2.3	4.4
2006	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	88	58	1	7	2.1	2.9	5.0
2007	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	89	66	1	7	2.2	3.4	5.6
2008	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	90	73	1	7	2.3	4.0	6.3
2009	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	91	81	1	7	2.3	4.6	6.9
2010	4.2	9.3	11.6	6.8	8.8	27.4	21.0	6.3	7.7	92	88	1	7	2.4	5.2	7.5
Total																52.0

NREL Case #1 — Future Coal Costs

The first sensitivity that NREL examined was the very favorable assumptions that RDI adopted for future coal generation costs. These assumptions fall into three main categories: (1) the capital cost of a new coal-fired plant, (2) the price of coal, and (3) the capacity factor of the plant.

Coal Plant Capital Cost

RDI assumes a capital cost of $956/kW for a new 400-MW coal-fired power plant to be constructed in the Northeast that incorporates a wet flue-gas desulfurization (FGD) system for emissions control. RDI attributes this cost estimate to Duke/Flour Daniel. However, this cost estimate is 20% below the cost of a new coal-fired plant adopted by the Electric Power Research Institute (EPRI) in its *Technical Assessment Guide* (*TAG*).[1] The EPRI *TAG* is a standardized utility industry primer that provides generic technology cost and performance data that utilities can use to perform preliminary screening analyses of resource options. Although the *TAG* may be useful for ranking different technology options for planning purposes, the cost data do not necessarily reflect the actual utility cost of installing a power plant today. However, no new utility-owned, coal-fired capacity has been brought into service since 1992 from which current market cost data can be derived. Data for 1991 from RDI's own POWERdat® database yields a cost range of from $705/kW for a 705.5-MW addition to a pre-existing coal plant (J.H. Miller—Alabama Power Co.) to $1,781/kW for a new 349-MW plant (TNP One—Texas-New Mexico Power Co.).[2] Because of the absence of current market data for coal plants, NREL adopted a standard *TAG* coal plant representation — a 300-MW pulverized coal plant with FGD sited in the Southeast.

NREL investigated potential cost improvements for advanced coal technologies. However, an examination of both EPRI and EIA cost estimates for advanced coal technologies found that these technologies offer no significant cost advantage over conventional pulverized coal technology. In fact, the projected costs of these advanced technologies would be, in most cases, significantly higher than the conventional coal plant cost adopted for the NREL analysis.

Coal Price Projections

RDI utilizes a proprietary forecast for coal prices that is some 20% below cost projections from other sources. NREL substituted the latest coal price forecast made by the Energy Information Administration (EIA), the independent statistical arm of the U.S. Department of Energy (DOE).[3] Figure 1 illustrates the differences in the RDI and EIA forecasts.

Coal Plant Capacity Factor

Finally, RDI assumes an average capacity factor of 80% for its base coal plant, which is much higher than the actual operating experience for the nation's existing stock of coal generating plants. According to the North American Electric Reliability Council, the average capacity factor for all operating coal-fired power plants in the United States was 60% from 1990 to 1994.[4] The *TAG* uses a 65% capacity factor as most representative of a "life-time levelized value" for new base-load power plants, including coal.[5] The NREL recalculation adopts the *TAG* convention of a 65% capacity factor for the coal plant characterization.

When these changes are made to the RDI coal assumptions, the levelized cost of energy from the generic coal option is recalculated to be 5.36¢/kWh, compared to the 3.82¢/kWh characterized in the CEED/RDI report and the 4.20¢/kWh used by RDI in its cost spreadsheet (Table 2).[6] The difference in the coal cost assumptions account for $8.6 billion of the $52 billion CEED/RDI renewables cost estimate. The full spreadsheet recalculation is provided in Table 3.

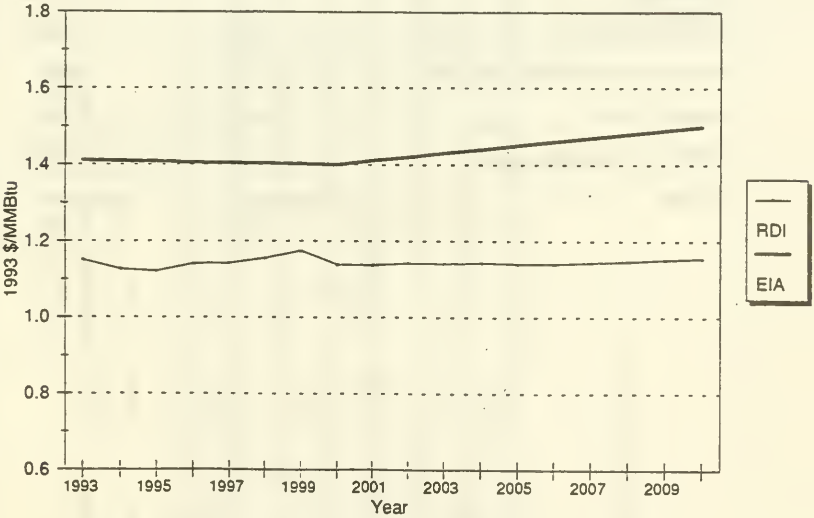

Figure 1. RDI and EIA forecasts for delivered coal prices

Table 2. Comparison of Pulverized Coal Plant Assumptions

	CEED/RDI	NREL
Specific Technology	Wet FGD	Subcritical/Limestone Forced Oxidation
Region	Northeast	Southeast
Plant Size (MW)	400	300
Total Plant Cost ($/kW)	956	1,195
Average Delivered Fuel Price ($/MMBtu)	1.16	1.46
O&M Costs		
Variable O&M (¢/kWh)	0.23	0.29
Fixed O&M ($/kW-yr)	43.48	41.48
Average Annual Heat Rate (Btu/kWh)	9550	9830
Capacity Factor	80%	65%
Levelized Cost of Energy (¢/kWh)	3.82	5.36
Source	Duke Flour/Daniel RDI	EPRI/TAG EIA

Table 3. NREL Case #1 Recalculations

	Levelized Cost of Energy (¢/kWh)							Weighted Price Difference (¢/kWh)		Forecast (billion kWh)		Annual Growth (billion kWh)		Cost Difference (billion $)		
Year	Coal	WTE	Biomass	Wind	Geothermal	PV	Solar Thermal	Combust.	Other	Combust.	Other	Combust.	Other	Combust.	Other	Total
1995	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	54	21					
1996	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	57	23	3	2	0.1	0.1	0.3
1997	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	59	25	3	2	0.3	0.2	0.5
1998	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	62	26	3	2	0.4	0.4	0.8
1999	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	64	28	3	2	0.5	0.5	1.0
2000	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	67	30	3	2	0.7	0.6	1.3
2001	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	71	34	4	4	0.9	0.9	1.7
2002	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	75	38	4	4	1.1	1.1	2.2
2003	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	79	43	4	4	1.3	1.4	2.7
2004	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	83	47	4	4	1.5	1.7	3.2
2005	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	87	51	4	4	1.7	2.0	3.6
2006	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	88	58	1	7	1.7	2.4	4.2
2007	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	89	66	1	7	1.8	2.9	4.7
2008	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	90	73	1	7	1.8	3.4	5.2
2009	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	91	81	1	7	1.9	3.9	5.8
2010	5.4	9.3	11.6	6.8	8.8	27.4	21.0	5.1	6.5	92	88	1	7	1.9	4.4	6.3
Total																43.4

Note: RDI base case with EPRI TAG coal plant cost and EIA coal price forecast.

NREL Case #2 — Costs of Renewable Energy Technologies

The largest difference in the RDI and NREL cost estimates is due to assumptions regarding the costs of the various renewable energy technologies. Although RDI claims to have obtained "the most current and accurate information possible" on the cost of renewable energy technologies, NREL found that this was not the case. While RDI postulates a cost range of 6.8¢/kWh to 27.4¢/kWh for various renewables, the results of several recent utility competitive bidding solicitations show that many different types of renewables projects have been offered in a price range of 4.5¢/kWh to 6.0¢/kWh.[7] In June 1995, Northern States Power announced a winning levelized bid price of 3.0¢/kWh for development of a 100-MW wind project.[8] Furthermore, RDI assumes no future improvements in renewable energy costs from the high assumed values.

In this analysis, NREL used renewable technology costs prepared by the DOE renewable energy technology programs.[9] The DOE costs incorporate expected technology and cost improvements through the year 2010. Table 4 compares the DOE and RDI renewable technology cost figures. We reiterate here that no cost improvements were assumed for coal-fired generation because both EPRI and EIA generally project higher costs from advanced coal technologies.

When the more realistic renewable energy costs and projected cost improvements are combined with the adjusted costs for future coal generation, the CEED/RDI renewables cost estimate is reduced by another $31.6 billion. Table 5 provides the recalculation results for this case.

Table 4. Comparisons of Levelized Cost Estimates for Renewable Energy Technologies

		RDI Assumptions (1993 ¢/kWh)	DOE Projections (1993 ¢/kWh)
Wind	1995	6.8	5.3
	2000	6.8	4.1
	2005	6.8	3.9
	2010	6.8	3.5
Geothermal	1995	8.8	5.2
	2000	8.8	4.0
	2005	8.8	3.8
	2010	8.8	3.7
Biomass	1995	11.6	8.5
	2000	11.6	8.1
	2005	11.6	7.5
	2010	11.6	7.2
PV	1995	27.4	21.8
	2000	27.4	16.4
	2005	27.4	13.1
	2010	27.4	8.7
Solar Thermal	1995	21.0	10.5
	2000	21.0	8.6
	2005	21.0	8.1
	2010	21.0	8.1
Waste to Energy	1995	9.3	8.2
	2000	9.3	8.2
	2005	9.3	8.2
	2010	9.3	8.2

Table 5. NREL Case #2 Recalculations[1]

	Levelized Cost of Energy (¢/kWh)							Weighted Price Difference (¢/kWh)		Forecast (billion kWh)		Annual Growth (billion kWh)		Cost Difference (billion $)		
Year	Coal	WTE[2]	Biomass	Wind	Geothermal	PV	Solar Thermal	Combust.	Other	Combust.	Other	Combust.	Other	Combust.	Other	Total
1995	5.4	8.2	8.5	5.3	5.2	21.8	10.5	3.0	2.6	54	21					
1996	5.4	8.2	8.4	5.1	4.9	20.7	10.1	2.9	2.2	57	23	3	2	0.1	0.0	0.1
1997	5.4	8.2	8.3	4.8	4.7	19.6	9.7	2.9	1.9	59	25	3	2	0.2	0.1	0.2
1998	5.4	8.2	8.2	4.6	4.6	18.5	9.4	2.9	1.5	62	26	3	2	0.2	0.1	0.3
1999	5.4	8.2	8.2	4.3	4.2	17.5	9.0	2.8	1.2	64	28	3	2	0.3	0.1	0.4
2000	5.4	8.2	8.1	4.1	4.0	16.4	8.8	2.8	0.8	67	30	3	2	0.4	0.1	0.5
2001	5.4	8.2	8.0	4.0	4.0	15.7	8.5	2.7	0.7	71	34	4	4	0.5	0.2	0.6
2002	5.4	8.2	7.9	4.0	3.9	15.1	8.4	2.7	0.5	75	38	4	4	0.6	0.2	0.8
2003	5.4	8.2	7.7	4.0	3.9	14.4	8.3	2.6	0.4	79	43	4	4	0.7	0.2	0.9
2004	5.4	8.2	7.6	3.9	3.9	13.7	8.2	2.6	0.3	83	47	4	4	0.8	0.2	1.0
2005	5.4	8.2	7.5	3.9	3.8	13.1	8.1	2.5	0.2	87	51	4	4	0.9	0.2	1.1
2006	5.4	8.2	7.5	3.8	3.8	12.2	8.1	2.5	0.0	88	58	1	7	0.9	0.2	1.1
2007	5.4	8.2	7.4	3.7	3.8	11.3	8.1	2.4	(0.1)	89	66	1	7	0.9	0.2	1.2
2008	5.4	8.2	7.3	3.6	3.7	10.6	8.1	2.4	(0.3)	90	73	1	7	1.0	0.2	1.2
2009	5.4	8.2	7.3	3.6	3.7	9.6	8.1	2.4	(0.4)	91	81	1	7	1.0	0.2	1.2
2010	5.4	8.2	7.2	3.5	3.7	8.7	8.1	2.3	(0.6)	92	88	1	7	1.0	0.1	1.1
Total:																11.8

Notes: 1. RDI base case scenario with EPRI TAG coal plant cost, EIA coal price forecast, and DOE levelized cost projections for renewables.
2. No DOE estimates for WTE. EPRI TAG and RDI numbers were used.

NREL Case #3 — Market Penetration of Renewable Energy Technologies

The final calculation sensitivity relates to the market penetration rate of the different renewable energy technologies. It is reasonable to assume that those technologies that are economically competitive will penetrate the market faster than those that are only marginally cost effective. Also, there are initial limitations on how quickly an industry can gear up to supply its product.

Keeping this in mind, NREL substituted more orderly technology penetration scenarios for the fixed market share approach used by RDI (Tables 6 and 7). The NREL penetration assumptions also more closely resemble the current energy and capacity contributions from renewable power sources. Within the combustion-oriented renewable energy group, NREL changed the ratio of biomass to WTE; NREL used 75/25 instead of RDI's 50/50. Within the "naturally occurring" group, contributions from geothermal, wind, solar thermal, and photovoltaics (PV) more closely follow the EIA-adopted forecast for individual renewable technologies; RDI used a fixed 37.5/37.5/12.5/12.5 market share ratio.[10]

The change in market penetration assumptions, when combined with the coal and renewable cost adjustments, yields a further reduction of $9.9 billion from the CEED/RDI $52 billion renewables cost estimate (Table 8). This leaves a total cost estimate of $1.9 billion over 15 years to achieve a doubling in the contribution of nonhydro renewable energy sources to the nation's electricity supply mix.

Table 6. RDI Base Case Renewable Energy Growth Scenario

	Forecast		Combustion				Naturally Occurring							
	Combust.	Nat. Occur	WTE		Biomass		Wind		Geothermal		PV		Solar Thermal	
Year	(billion kWh)	(billion kWh)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)
1995	54	21	27.0	4,403	27.0	4,403	7.9	3,100	7.9	999	2.6	1,427	2.6	749
1996	57	23	28.3	4,615	28.3	4,615	8.6	3,366	8.6	1,084	2.9	1,549	2.9	813
1997	59	25	29.6	4,827	29.6	4,827	9.2	3,631	9.2	1,170	3.1	1,672	3.1	878
1998	62	26	30.9	5,039	30.9	5,039	9.9	3,897	9.9	1,256	3.3	1,794	3.3	942
1999	64	28	32.2	5,251	32.2	5,251	10.6	4,163	10.6	1,341	3.5	1,916	3.5	1,006
2000	67	30	33.5	5,463	33.5	5,463	11.3	4,428	11.3	1,427	3.8	2,038	3.8	1,070
2001	71	34	35.5	5,789	35.5	5,789	12.8	5,048	12.8	1,627	4.3	2,324	4.3	1,220
2002	75	38	37.5	6,115	37.5	6,115	14.4	5,668	14.4	1,826	4.8	2,609	4.8	1,370
2003	79	43	39.5	6,442	39.5	6,442	16.0	6,288	16.0	2,026	5.3	2,895	5.3	1,520
2004	83	47	41.5	6,768	41.5	6,768	17.6	6,908	17.6	2,226	5.9	3,180	5.9	1,670
2005	87	51	43.5	7,094	43.5	7,094	19.1	7,528	19.1	2,426	6.4	3,465	6.4	1,819
2006	88	58	44.0	7,175	44.0	7,175	21.9	8,621	21.9	2,778	7.3	3,988	7.3	2,083
2007	89	66	44.5	7,257	44.5	7,257	24.7	9,713	24.7	3,130	8.2	4,471	8.2	2,347
2008	90	73	45.0	7,339	45.0	7,339	27.5	10,805	27.5	3,482	9.2	4,974	9.2	2,611
2009	91	81	45.5	7,420	45.5	7,420	30.2	11,898	30.2	3,834	10.1	5,477	10.1	2,875
2010	92	88	46.0	7,502	46.0	7,502	33.0	12,990	33.0	4,188	11.0	5,980	11.0	3,139
								10%		10%		10%		10%
						70% CF		29% CF		90%		21%		41% CF

Table 7. NREL's Alternative Renewable Energy Growth Scenario

	Forecast		Combustion				Naturally Occurring							
	Combust.	Nat. Occur	WTE		Biomass		Wind		Geothermal		PV		Solar Thermal	
Year	(billion kWh)	(billion kWh)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)	(billion kWh)	(MW)
1995	54	21	13.5	2,202	40.5	6,605	3.4	1,605	16.8	2,370	0.0	10	0.8	364
1996	55	22	13.6	2,224	40.9	6,671	3.9	1,870	17.1	2,414	0.1	25	0.9	406
1997	55	23	13.8	2,246	41.3	6,738	4.5	2,153	17.4	2,452	0.1	42	1.0	449
1998	58	24	13.9	2,268	41.7	6,805	5.1	2,453	17.6	2,484	0.2	59	1.1	495
1999	56	25	14.1	2,302	42.4	6,907	5.8	2,770	17.8	2,509	0.2	78	1.2	543
2000	57	26	14.3	2,337	43.0	7,011	6.5	2,467	17.9	2,507	0.3	86	1.3	594
2001	58	27	14.6	2,383	43.8	7,150	7.0	2,654	18.3	2,550	0.3	106	1.4	641
2002	60	29	15.1	2,465	45.2	7,365	7.8	2,980	19.2	2,682	0.4	132	1.6	715
2003	83	32	15.7	2,553	47.0	7,660	9.0	3,387	20.7	2,897	0.5	167	1.8	818
2004	66	36	16.4	2,681	49.3	8,043	10.4	3,946	22.8	3,189	0.6	211	2.1	953
2005	69	41	17.3	2,815	51.8	8,445	12.3	4,472	25.4	3,526	0.8	267	2.5	1,123
2006	73	47	18.2	2,970	54.6	8,909	15.0	5,488	27.9	3,872	1.0	337	3.0	1,374
2007	77	55	19.3	3,148	57.9	9,443	18.7	6,798	31.2	4,333	1.3	431	3.7	1,708
2008	82	65	20.5	3,337	61.4	10,011	23.4	8,507	35.2	4,887	1.7	551	4.7	2,137
2009	87	76	21.7	3,537	65.1	10,612	28.9	10,499	39.2	5,440	2.1	694	5.8	2,637
2010	92	88	23.0	3,751	69.0	11,252	35.2	12,140	43.1	5,931	2.6	861	7.0	3,215
								33		32%		34%		25%

Table 8. NREL Case #3 Recalculations

	Levelized Cost of Energy (¢/kWh)							Weighted Price Difference (¢/kWh)		Forecast (billion kWh)		Annual Growth (billion kWh)		Cost Difference (billion $)		
Year	Coal	WTE²	Biomass	Wind	Geothermal	PV	Solar Thermal	Combust.	Other	Combust.	Other	Combust.	Other	Combust.	Other	Total
1995	5.4	8.2	8.5	5.3	5.2	21.8	10.5	3.1	0.1	54	21					
1996	5.4	8.2	8.4	5.1	4.9	20.7	10.1	3.0	-0.1	55	22	1	1	0.02	(0.00)	0.0
1997	5.4	8.2	8.3	4.8	4.7	19.6	9.7	2.9	-0.4	55	23	1	1	0.03	(0.00)	0.0
1998	5.4	8.2	8.2	4.6	4.5	18.6	9.4	2.9	-0.6	56	24	1	1	0.05	(0.01)	0.0
1999	5.4	8.2	8.2	4.3	4.2	17.5	9.0	2.8	-0.8	56	25	1	1	0.07	(0.02)	0.1
2000	5.4	8.2	8.1	4.1	4.0	16.4	8.6	2.7	-1.0	57	26	1	1	0.09	(0.03)	0.1
2001	5.4	8.2	8.0	4.0	4.0	15.7	8.5	2.7	-1.0	58	27	1	1	0.12	(0.04)	0.1
2002	5.4	8.2	7.9	4.0	3.9	15.1	8.4	2.6	-1.0	60	29	2	2	0.17	(0.06)	0.1
2003	5.4	8.2	7.7	4.0	3.9	14.4	8.3	2.5	-1.0	63	32	2	3	0.23	(0.09)	0.1
2004	5.4	8.2	7.6	3.9	3.9	13.7	8.2	2.4	-1.1	66	36	3	4	0.31	(0.13)	0.2
2005	5.4	8.2	7.5	3.9	3.8	13.1	8.1	2.3	-1.1	69	41	3	5	0.38	(0.19)	0.2
2006	5.4	8.2	7.5	3.8	3.8	12.2	8.1	2.3	-1.1	73	47	4	6	0.47	(0.25)	0.2
2007	5.4	8.2	7.4	3.7	3.8	11.3	8.1	2.2	-1.1	77	55	4	8	0.57	(0.34)	0.2
2008	5.4	8.2	7.3	3.6	3.7	10.5	8.1	2.2	-1.2	82	65	6	10	0.67	(0.46)	0.2
2009	5.4	8.2	7.3	3.6	3.7	9.6	8.1	2.1	-1.2	87	76	5	11	0.77	(0.60)	0.2
2010	5.4	8.2	7.2	3.5	3.7	8.7	8.1	2.1	-1.3	92	88	5	12	0.88	(0.75)	0.1
Total																1.9

Note: NREL's alternative renewable energy growth scenario with EPRI TAG coal plant cost, EIA coal price forecast, and DOE levelized cost projections for renewables

Endnotes

1. See Electric Power Research Institute, *TAG™ Technical Assessment Guide: Electricity Supply — 1993*, EPRI TR-102276-V1R7, Volume 1: Rev. 7, June 1993.

2. Also in 1991, Cincinnati Gas and Electric Company brought its Zimmer plant (1426 MW) on line at a cost of $2,286/kW. However, the Zimmer plant was a nuclear-to-coal plant conversion and thus is not reflective of coal-only construction costs.

3. U.S. Energy Information Administration, *Annual Energy Outlook 1995 with Projections to 2010*, DOE/EIA-0383(95), January 1995.

4. North American Electric Reliability Council, *Generating Unit Statistics 1990-1994*, June 1995.

5. Electric Power Research Institute, *Op Cit*, p. 2-2.

6. Additional differences can be noted in the O&M cost and heat rate assumptions.

7. These include bidding solicitations conducted by New England Power, Portland General Electric, and the three California investor-owned utilities.

8. The wind energy bid price accounts for the net impact of the federal production tax credit and a state property tax levy. National Renewable Energy Laboratory, *State Renewable Energy News*, Summer 1995.

9. U.S. Department of Energy, Office of Utility Technologies, Renewable Energy Technology Characterizations, 1994. The one exception is WTE technology for which DOE cost estimates were not available; NREL used WTE plant cost data from the *TAG* and RDI's waste fuel cost data.

10. U.S. Energy Information Administration, *Op Cit*.

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13. ABSTRACT *(Maximum 200 words)*

This report is an analysis of a coal industry study critical of renewable energy. The National Renewable Energy Laboratory (NREL) was commissioned by the U.S. Department of Energy to review the assumptions in the coal report entitled, *Energy Choices in a Competitive Era: The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix*, prepared by Resource Data International, Inc. (RDI) for the Center for Energy and Economic Development (CEED), an umbrella organization of pro-coal interests. The NREL analysis finds that the conclusions in the CEED/RDI study are based on faulty data and assumptions regarding the comparative economics of coal and renewable energy development. After correcting the errors, NREL finds that a modest growth path of renewable resource development would cost the nation little more than the projected electricity market cost for fossil-fuel-based power generation, even before considering the environmental benefits that would accompany this development.

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Q5. In a letter to GAO dated April 16, 1996, signed by Ms. Godley, Mr. Chupka and yourself, the following was stated in the last paragraph on page 2:

> "We understand that the GAO was under pressure to finalize this record and note that it was released one week prior to the expected markup of the FY 1997 Budget Resolution."

Q5a. Who specifically informed you of such "pressure"?

Q5b. Who specifically applied this "pressure"? Are you implying that any Members of this Subcommittee or staff "pressured" GAO to finalize this study, and if so, would you please identify them and provide detailed documentation of such "pressure"?

A5a & A5b. In one of the final interviews between GAO and DOE, the GAO indicated to us that they had been asked to hurry up and finish their report. We have no knowledge of who made this request. We are certainly not implying that any Member of this Subcommittee or staff "pressured" GAO to finalize this study.

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